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SCIENCE 7

Module


5

Planet Earth



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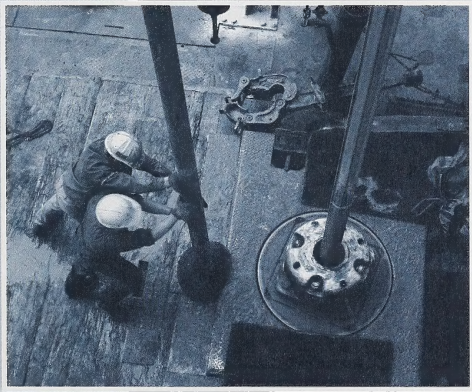
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SCIENCE 7

Module 5

Planet Earth



Learning
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Science 7
Module 5: Planet Earth
Student Module Booklet
Learning Technologies Branch
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The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	



You may find the following Internet sites useful:

- Alberta Learning, <http://www.learning.gov.ab.ca>
- Learning Technologies Branch, <http://www.learning.gov.ab.ca/lrb>
- Learning Resources Centre, <http://www.lrc.learning.gov.ab.ca>

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Welcome to

SCIENCE 7

Module

1

Interactions and Ecosystems

Module

2

Plants for Food and Fibre

Module

3

Heat and Temperature

Module

4

Structures and Forces

Module

5

Planet Earth

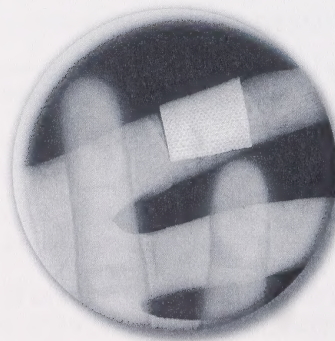
Contents

Resources	6
Before You Begin	6
Icons	7
Overview	8
Assessment	9
Planning Ahead	10
Section 1: Rocks and Minerals	11



Lesson 1: Minerals	12
Lesson 2: Rocks and the Rock Cycle	23
Lesson 3: Erosion	39
Section 1 Review	44
Conclusion	44

Section 2: Earth's Changing Face	45
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Lesson 1: The Moving Crust	46
Lesson 2: Earthquakes	54
Lesson 3: Volcanoes	67
Lesson 4: Mountains	72
Section 2 Review	76
Conclusion	76

Section 3: Fossil Formation and Earth's History 77



Lesson 1: Fossils.....	78
Lesson 2: Geologic Time	82
Lesson 3: Fossil Fuels	88
Section 3 Review.....	91
Conclusion.....	91

Summary 92

Appendix 93

Glossary	94
Suggested Answers	96
Image Credits	114
Cut-out Learning Aids	117



Resources

Textbook

To complete the course, you need the textbook *ScienceFocus 7*.

Multimedia

Attached to Module 1 of this course is a CD titled *Science 7 Multimedia*. This CD contains multimedia segments designed to help you better understand particular concepts presented in this course. Ask your teacher or home instructor if you need help using this CD.

Materials and Apparatus

A list of materials and apparatus is given on page 10 of each Student Module Booklet. These items are needed to complete the module. Some of the materials and apparatus may be provided at your local school lab. If you don't have access to a school lab, you will need to get the loan kit. Talk to your teacher for more information.

Before You Begin

Organize your materials and work area before you begin: Student Module Booklet, textbook, notebook, pens, pencils, and so on. Make sure you have a quiet area in which to work, away from distractions.

Because response lines are not provided in the Student Module Booklet, you'll need a looseleaf binder or notebook to respond to questions and complete charts. It's important to keep your lined paper handy as you work through the material and to keep your responses together in a notebook or binder for review purposes later.

Refer to the Planning Ahead page for directions on what you need to do before you start this module.

Icons

This is one of five Student Module Booklets for Science 7. As you progress through this module, you will meet several icons.



Do Ahead

Some preparation must be started well ahead of the activity or investigation.



Teacher or Home Instructor

The teacher or home instructor should be contacted for help, approval of some procedure, or checking answers.



Assignment Booklet

Work needs to be done in one of the Assignment Booklets.



Safety

You must be very careful when you see this symbol.



Textbook

A reference is made to *ScienceFocus 7*, the textbook accompanying this course.



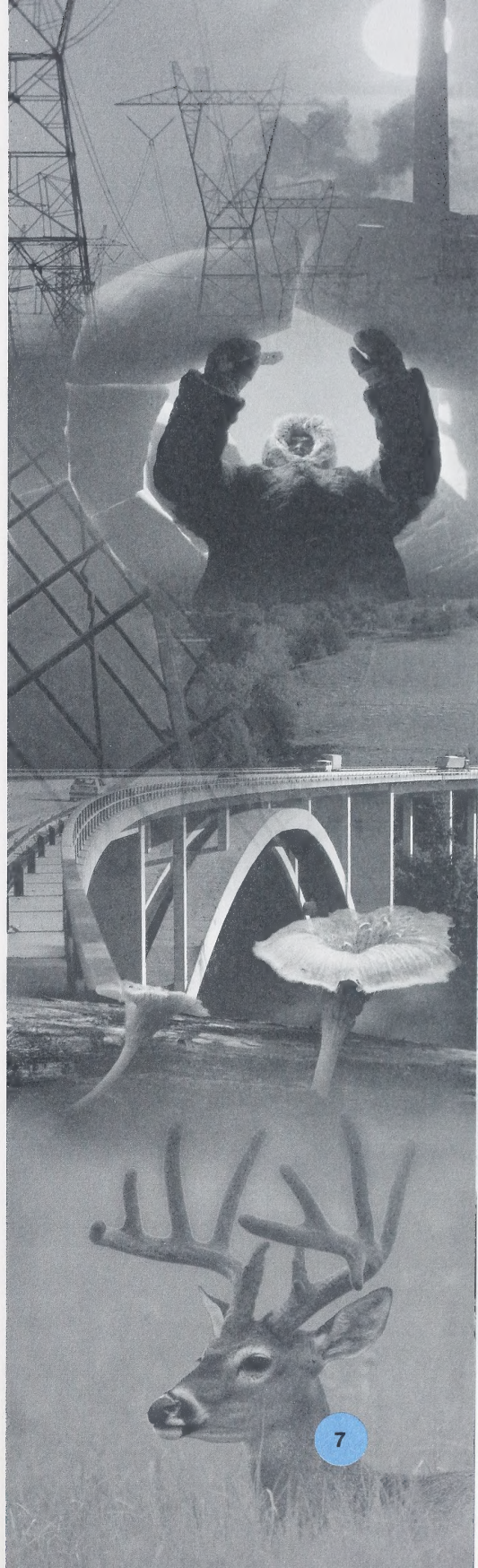
Internet

This is a reference to the Internet. **Note:** Any Internet website given is subject to change.



Multimedia

This is a reference to the *Science 7 Multimedia* CD.





Overview

Module

5

Planet Earth

Section 1

Rocks and Minerals

Section 2

Earth's Changing Face

Section 3

Fossil Formations and Earth's History

What is your reaction to the photograph on page 350 of the textbook? Do the enormous energy and volume of volcanic ash billowing from this volcano surprise you? What is its source of power? Will it envelop the vehicle in the foreground? What will the landscape look like when the dust settles? From film and news reports, you are likely quite familiar with volcanic eruptions and earthquakes. These are spectacular and devastating indicators of activity within Earth's interior and its outer skin, the crust.

Are you aware of the slower, constant changes occurring? You don't see mountains growing and being broken down, parts of the crust moving, or rock changing into soil. These processes take a long time. It may seem to you that very little changes, other than changes from the catastrophic events of earthquakes and volcanic eruptions. Nonetheless, Earth's crust and interior are constantly changing. Studying these changes provides scientists a view of the past.

In this module you will explore Earth's crust. For more information about this module, read the introductory information of "Unit 5: Planet Earth" on pages 350 to 353 of the textbook.

Assessment

This booklet is the Student Module Booklet. It will show you, step by step, how to advance through Module 5: Planet Earth.

This module, Planet Earth, has three sections. Each section is built of lessons. Within the lessons, there are readings, investigations, activities, and questions for you to do. By completing these lessons, you will

- discover scientific concepts and skills
- develop a positive attitude toward science
- practise or apply these new concepts and skills

There are suggested answers in the Appendix of this Student Module Booklet. They provide you with a way to check your understanding. Your teacher will also provide you with feedback on your progress throughout the module.

At several points in this module, you will be directed to the accompanying Assignment Booklets. Your grading in this module is based on the assignments you submit for assessment. In this module you are expected to complete three section assignments and a final module assignment.

The mark distribution is as follows:

Assignment Booklet 5A	
Section 1 Assignment	28 marks
Section 2 Assignment	29 marks
Assignment Booklet 5B	
Section 3 Assignment	26 marks
Final Module Assignment	<u>26 marks</u>
TOTAL	109 marks



Planning Ahead

Here is a list of materials and apparatus you will need to complete this module.

Section 1	Section 2	Section 3
<ul style="list-style-type: none"><input type="checkbox"/> mineral samples (optional)<input type="checkbox"/> magnifying glass<input type="checkbox"/> iron nail<input type="checkbox"/> copper penny (or piece of copper)<input type="checkbox"/> utility knife<input type="checkbox"/> steel file<input type="checkbox"/> streak plate (or file)<input type="checkbox"/> mineral guidebook<input type="checkbox"/> sandpaper<input type="checkbox"/> emery paper<input type="checkbox"/> vinegar (or 10% hydrochloric acid)<input type="checkbox"/> rock samples<input type="checkbox"/> hand lens<input type="checkbox"/> watch glass<input type="checkbox"/> tongs (or tweezers)<input type="checkbox"/> eyedropper	<ul style="list-style-type: none"><input type="checkbox"/> scissors<input type="checkbox"/> glue<input type="checkbox"/> world map<input type="checkbox"/> blue paper<input type="checkbox"/> paper<input type="checkbox"/> paints, markers, or coloured pencils<input type="checkbox"/> tape<input type="checkbox"/> compass<input type="checkbox"/> pencil<input type="checkbox"/> map of Canada<input type="checkbox"/> Styrofoam® blocks<input type="checkbox"/> graph paper<input type="checkbox"/> cardboard boxes (or blocks of wood)<input type="checkbox"/> world map with latitude and longitude lines<input type="checkbox"/> flexible Styrofoam® sheets	<ul style="list-style-type: none"><input type="checkbox"/> 5 Styrofoam® bowls<input type="checkbox"/> spoons<input type="checkbox"/> shells or plastic animals<input type="checkbox"/> graduated cylinder<input type="checkbox"/> plaster of Paris<input type="checkbox"/> sand<input type="checkbox"/> clay<input type="checkbox"/> pebbles<input type="checkbox"/> adding machine tape<input type="checkbox"/> metre-stick (or ruler)<input type="checkbox"/> pencil<input type="checkbox"/> water<input type="checkbox"/> coloured pencils<input type="checkbox"/> glue<input type="checkbox"/> scissors

In Section 1: Lesson 2, you will need to find five different rock samples to use in “Find Out Activity: Rock Identification.”

In Section 1: Lesson 3 you will need samples of specific rocks to use in “Investigation 5-D: Rocks that Fizz.”



If you have access to the Internet, you may want to check out some of the links for this module ahead of time. Go to the following site:

<http://www.mcgrawhill.ca/school/booksites/sciencefocus+7/student+resources/toc/index.php>

Section 1

Rocks and Minerals

Look closely at the pictures below. Chances are that at least one of these landscapes will look familiar to you. What do you think has happened to create these scenes? Common to all of the scenes is the handiwork of water. You can see it directly in the outer two pictures. There is a riverbed carved by flowing water showing clearly. The middle picture, though, only shows the crevices created by running water. You have to figure out what has happened from the evidence. This is particularly true when dealing with Earth Science.

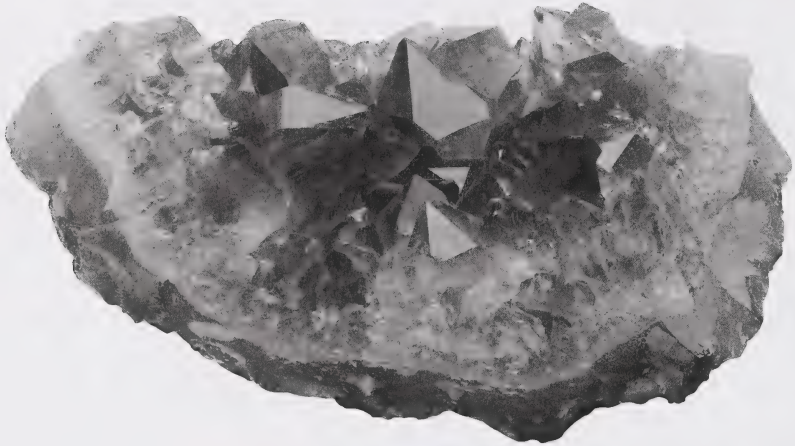
These pictures also show a number of other important features. Notice that each one shows plants and rocks. Which of these do you think would be easiest to study? Did you say rocks because you think they never change, making them easier to study? In some ways you would be right, but you would also find it hard to explain a lot of things. For example, how did the rock form? How long ago did it form? Why doesn't it have large crystals in it? Why is it so different from other rocks nearby?

In this section you will study what rocks are made of and how they are formed by the processes of the rock cycle. You will likely be able to answer the previous questions when you are finished.



Lesson 1: Minerals

Have you ever returned from a vacation with a special rock or mineral sample in your bag? Perhaps you brought home something like an amethyst geode (like the one shown here). What makes people choose souvenirs like an amethyst geode? Is it because of its shape? neat colours? interesting crystals?

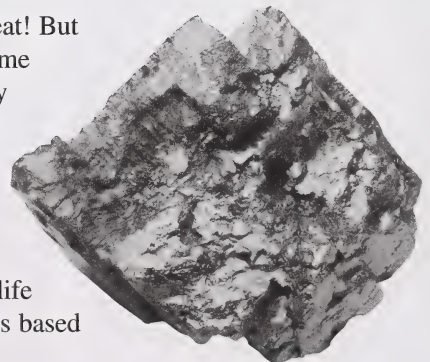


Rocks are formed from **minerals**. These minerals and the way they are formed and combined determine the rock's appearance. You may also know that rocks and minerals are economically and geologically important. These natural substances supply a large number and type of materials and chemicals. Rocks and minerals carry a record of the Earth's past and reveal glimpses into the Earth's future.

In this lesson you will investigate a variety of simple techniques used by geologists to identify minerals. You will also research the locations of economically important mineral deposits in Alberta and Canada.

Properties of Minerals

This rock is beautiful, interesting, weird, and neat! But what is it? How was it formed? Where did it come from? What is it used for? Actually, you already know a great deal about the object on the right. Just by looking at its properties (features), you can tell if it is living or non-living and if it is plant, animal, or inorganic. You can predict whether it is heavy or light, is soft or hard, will burn or dissolve, or is edible or inedible. Daily life has taught you to classify objects and substances based on a wide variety of properties.





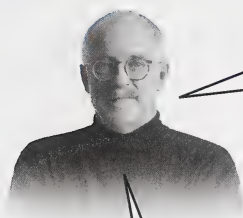
Some of the properties used to identify minerals are described later in the textbook. For now, read the introductory paragraphs of “Topic 1: Minerals” on page 354 of the textbook.

1. Write definitions for the following terms:

- *rock*
- *mineral*
- *crust*
- *element*
- *compound*
- *pure substance*



Compare your response with the one in the Appendix on page 96.



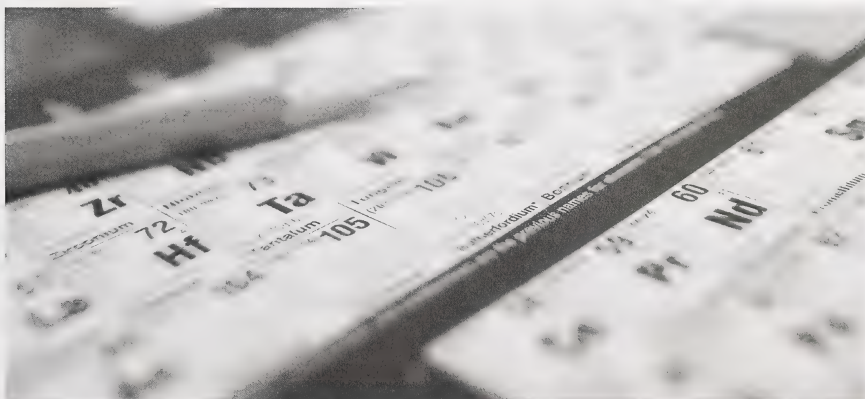
Do you remember that an atom, an extremely tiny particle, is the building block of all matter?

I remember now. But I don't understand how elements, compounds, and pure substances are related.



You will learn a lot more of the details in Science 9; but at this stage, it's a good idea to have a basic understanding. So, read on!

If a substance consists of only one type of atom, it is called an element. Elements are pure substances with their own specific properties (characteristics). These properties are always the same for a particular element and can be used to describe or identify it. There are 112 different atoms or elements. Most are not common. In fact, 99% of the Earth's crust is formed from only 10 elements.



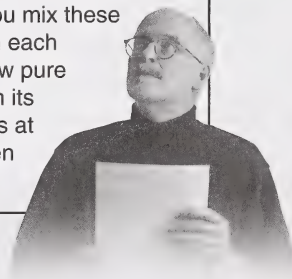
Study the following table.

Major Elements in Earth's Crust			
Element	Portion of Earth's Crust	Element	Portion of Earth's Crust
oxygen	46.60%	sodium	2.83%
silicon	27.72%	potassium	2.59%
aluminum	8.13%	magnesium	2.09%
iron	5.00%	titanium	0.40%
calcium	3.63%	hydrogen	0.14%



Gee, but when you look at the photographs in the textbook, it's pretty obvious that there are more than 10 different substances in the Earth's crust.

That's where compounds come in. When atoms of different kinds are "chemically bonded," they become a new pure substance with its own specific properties. These properties are different from those of the elements from which it is formed. It is the bond formed during a chemical reaction that creates a new compound from a mixture of different atoms. For example, oxygen and hydrogen are elements. If you mix these two gases and ignite them with a spark they react with each other and become chemically bonded, creating the new pure substance known as water. Water is very different from its component elements. Oxygen and hydrogen are gases at room temperature. Water is a liquid. We breathe oxygen and drink water.



Geology is a broad and interesting field with many applications in the commercial, industrial, and academic worlds. Investigate a geological question that is of interest to you! Read and follow "Looking Ahead" on page 353 of the textbook.

Mineral Identification—Hardness

Suppose, Halloween has just passed. You have a wide selection of candies in front of you. You are fussy about your candy, with definite likes and dislikes. How do you go about sorting your candy into “keepers” and “sharers” (the ones you will share with your family)? It is natural to consider the characteristics (properties) of the candy. Is it hard or soft? sweet or sour? crunchy or chewy? Will it melt in your mouth? What flavour is it? Based on these properties, you can identify the candies you like and classify each candy as a “keeper” or a “sharer.”

Minerals are like the Halloween candies; they have distinct properties (characteristics). They let you describe, identify, and classify them. Like candy, one of these properties is hardness. You would say that jawbreakers are hard, caramels are soft, and mints are usually somewhere in between. Scientific classification of mineral hardness is much more exact. This lets scientists around the world communicate clearly regardless of their language.



The Mohs hardness scale was created for the purpose of quantifying and standardizing this distinctive property of minerals. It ranks ten common minerals in a relative order of hardness from 1 to 10. The simplicity of this scale makes it a useful field method to establish the hardness of mineral samples. Other, more precise and complicated hardness scales have been devised for laboratory use.



If you have Internet access, you may wish to check on the Vickers scale and the Knoop scale. Use one of the Internet’s search engines to find this information.



Read “The Mohs Hardness Scale” on page 355 of the textbook.

2. A geologist is going into the field to identify rocks and minerals. She is taking a pencil, a steel pocket knife, a rock hammer, a bit of flint sandpaper, and, of course, her fingernails. Explain why she would need these items.



3. Would apatite scratch feldspar or vice versa? Why?



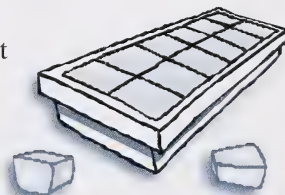
Compare your responses with those in the Appendix, page 96.

Mineral Identification—Crystal Structure

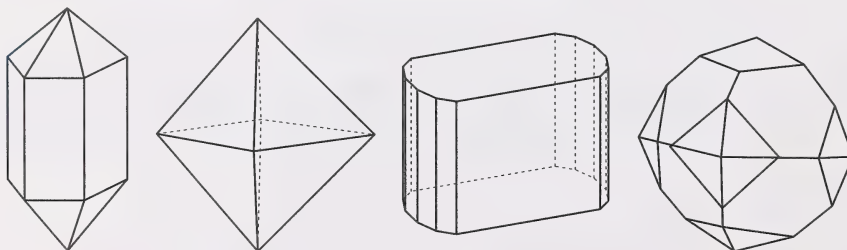


Has your curiosity ever lead you to take a close look at snowflakes? Snowflakes are water **crystals** formed into delicate patterns. Each of these snowflakes was formed from identically shaped crystals. They occurred in different, but similar, patterns. Notice, for example, that each flake has six “arms” and is hexagonal (six-sided) in shape. The similarities are created by the way water particles organize themselves as they solidify. The particles of most pure substances freeze (solidify) into a particular structure or pattern. The pattern is repeated over and over again as more and more particles freeze. The pattern can grow large enough to be seen with the naked eye; but the structure has to grow uninterrupted. This natural structure, built using the same basic shape again and again, is called a crystal.

Ice cubes and the ice on a local skating rink are built from the same basic shape as snowflakes. The pattern just doesn’t grow large enough for you to see it. Most solid pure substances are crystalline (solidified in a particular pattern or shape) on the particle level. But think about how tiny those particles are. So, while that ice cube is not a crystal, it is crystalline.

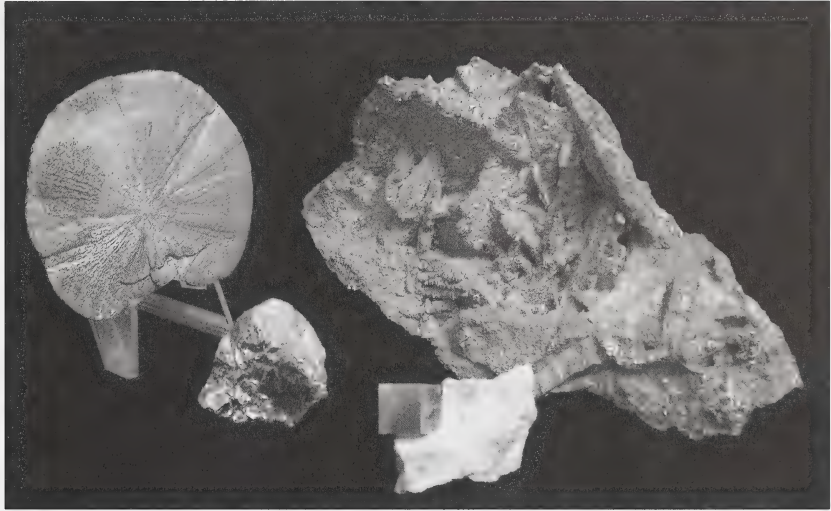


The same can be said for the pure substances—minerals—you are studying in this lesson. Most minerals solidify in a particular pattern that is based on the chemical properties of the mineral. There are six basic patterns (as shown in Table 5.2 on page 355 of the textbook). These basic patterns (crystal systems) have a number of variations, such as the following.



The crystal system is always the same for a particular mineral. This can be used to describe or help identify the mineral.

It is important to note that the basic crystalline pattern can grow in a variety of ways. It depends on the conditions that exist as the mineral forms a solid. Notice the variations in the pyrite in the photograph below. These pyrite samples look different on a macroscopic (naked eye) level. Yet, they all have the same crystalline structure. The crystalline structure of minerals can be found using X rays. Viewing very thin mineral slices with a strong microscope also works. With time and appropriate conditions, a crystal may grow enough that you can study it with your naked eye.



Review the information about crystals on page 355 of the textbook.

4. Define the term *crystal*.
5. You are trying to identify a mineral sample. You can see its crystal structure. Why isn't this enough to classify the mineral?



Compare your responses with those in the Appendix, page 96.

Mineral Identification—Combining Clues



The creatures in these pictures are a lot alike and, yet, a lot different. Imagine that you have made a new friend, Lionel, who lives in Australia. Lionel wants to learn about some of the wildlife in Canada. While talking over the phone with Lionel, you begin describing the creatures in the pictures.

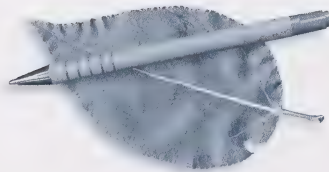
How can you describe these animals to Lionel without showing him the pictures? What characteristics would you use?

6. a. List five different characteristics of the chipmunk, bear, and fox.
- b. Could Lionel identify these animals if you only gave him one or two clues?



Compare your responses with those in the Appendix, page 96.

You identify and classify things every day. You use features like colour and size. Their characteristics let you distinguish between a blue pen and a shiny leaf. You probably do this so naturally that you don't even notice.



Scientists also need to classify and identify. With some objects and organisms, it is a life or death need. Earth scientists have a wide range of properties they can use, each providing useful clues to a mineral's identity.



7. Turn to pages 354 to 357 of the textbook. Study the minerals in Figures 5.1, 5.3, 5.4, 5.5, and 5.6. Think of properties that describe these minerals. Try to think of properties that help you identify these minerals. Make a list of at least five different properties. Don't include hardness or crystal structure in your list.



Compare your response with the one in the Appendix, page 96.



Read "Other Clues to Mineral Identification" on pages 356 and 357 of the textbook. It's an introduction to four simple properties used to describe and identify minerals.

8. Write definitions for the following terms:

- *impurities*
- *lustre*
- *streak*
- *cleavage*
- *fracture*



Compare your response with the one in the Appendix, page 97.

Going Further



Now that's a pretty penny! Did you know that pennies and all the other coins are made from minerals? Find out more about Canadian coins. Try "Internet Connect" on page 356 of the textbook.



In the next investigation you will use the properties of minerals to identify some samples. The focus is on understanding a few of the techniques that can be used to identify unknown minerals. Making a correct identification would be great. Even rock and mineral experts fall back on more sophisticated tests performed in laboratories. So, do your best to solve the mystery. Don't worry if you aren't sure of the names of the minerals. Remember, it's learning about the techniques that matters.

Investigation 5-A A Geologist's Mystery



Refer to the investigation on page 358 of the textbook. Read through the investigation first.

If you have access to one or more mineral samples, you can try to identify them yourself. Simply follow the procedure (with appropriate modifications) in the textbook. Be sure you have your home instructor's permission to test the samples. Some of the tests are destructive. You will also require a mineral guidebook or key. These may be found at your local library or on the Internet.

The following table lists the characteristics of several common minerals. Use this table to practise mineral identification.

Properties of Some Common Minerals						
Mineral	Colour	Lustre	Hardness	Streak	Reaction to Acid	Other Distinctive Properties
calcite	clear, white, variable	glassy	3	colourless, white	fizzes	can often see rainbows in clear samples
galena	blue-black, lead grey	shiny, metallic	2.5	grey to black	fizzes	rotten-egg smell given off when reacted with acid
hematite	brown-red, black, steel grey	dull, metallic	5–6.5	red-brown	none	can be attracted by a magnet, fractures
quartz	clear, white, variable	glassy, waxy	7	colourless, but too hard for ordinary tests	none	distinctively six-sided, pointed crystals
sulfur	bright yellow	waxy	1–2	white	none	smells like rotten eggs
biotite	black to dark brown	glassy	2–3	colourless (tends to chunk rather than powder)	none	crystals cleave into thin translucent sheets
graphite	silver-grey, black	greasy, metallic	1–2	black	none	feels slippery or greasy, rubs off easily
talc	green to white	dull, soapy	1	colourless	none	feels greasy



You will modify the equipment and procedure as necessary to fit your circumstances. Refer to Table 5.1 on page 355 of the textbook. Collect as many of the common objects that can be used for hardness testing as possible. You already have a magnifying glass in your loan kit.

If you don't have access to mineral samples, test the hardness of the common objects against each other. If you do have access to mineral samples, test their hardness against the common objects.

The streak test can be performed with a file instead of a streak plate. Filing the mineral, only as hard as necessary, will deposit mineral powder in the grooves of the file. You must base your judgments on the fine powder, not the small chunks. Clear powders or streaks can appear to be white if the powder is too thick or grainy or if it is on a white background.



Use vinegar (dilute acetic acid) instead of hydrochloric acid. Geologists often scrape or powder the mineral before doing an acid test. This provides a fresh surface and more surface area to react with the dilute acid.

Remember, some of the properties of minerals can vary due to impurities and the conditions under which they form.

end of investigation

9. Use the Properties of Some Common Minerals table to identify the following minerals.
 - a. dark brown, hardness = 2.5, cleaves into translucent sheets
 - b. white, colourless streak, hardness = 7, glassy lustre
 - c. white streak, hardness = 1, does not react with acid
 - d. metallic lustre, hardness = 5 to 5.5, black, red-brown streak



Check your responses with your teacher or home instructor.

Going Further



Dig for treasure in the library, on the Internet, or in the reference books around your home. Do “Find Out Activity: Dig for Treasure” on page 360 of the textbook. If you are especially interested in researching Alberta minerals, the economically important ones are calcium chloride, gypsum, marl, sodium sulfate, silica, salt, and sulfur.



You have now completed the new concepts for this lesson. To test what you covered, complete the following questions.

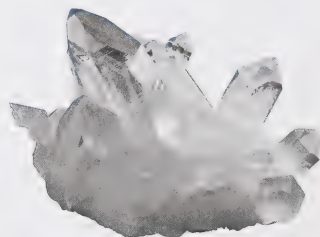


10. Answer questions 2, 3, and 4 of “Topic 1 Review” on page 360 of the textbook.

Check your responses with your teacher or home instructor.

Looking Back

The quartz crystals in the photograph would make an attractive souvenir of a great trip. But interesting rocks and minerals can also be found close to home. The more you know about them, the more they can tell you about the history of the area you live in.

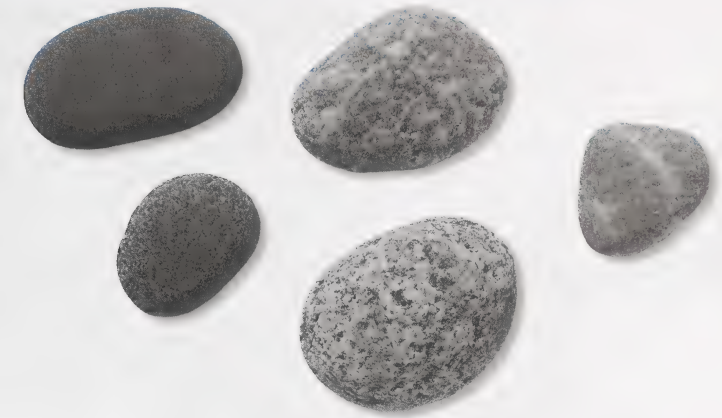


In this lesson you investigated some of the properties of minerals. These properties are used to describe, identify, and classify minerals. In the next lesson you will study how these minerals combine to form rocks.



Turn to page 1 of Assignment Booklet 5A and answer question 1.

Lesson 2: Rocks and the Rock Cycle



Perhaps that special souvenir you collected and brought home was, in fact, a rock rather than a mineral. Either way, it has a story to tell. The rocks shown here carry a record of their past. You can determine their origin, how they were formed, and some of what has happened to them over time by analyzing their mineral content, the type of crystals (or a lack of crystals), and their current shape.

In this lesson you will investigate how rocks are formed, classified, and identified. You will also determine how rocks continually change as they progress through the rock cycle.

Rock Families

Rocks have families too! Can you believe it? The members of each rock family are related to each other in a number of ways. In this lesson you get to climb the branches of their family trees. The rock families are closely interconnected by what is called the rock cycle.

Classifying substances, objects, and organisms is something humans often do. It organizes knowledge, helps identify patterns, and helps make inferences and predictions. Geologists group rocks into categories based first on how they form. These categories—igneous, sedimentary, and metamorphic—are called families. Rocks in the igneous family are formed from molten rock. The sedimentary family grows from sedimented rock particles or from minerals dissolved in water. Rocks from the metamorphic family are formed from pre-existing rock. They change in response to extreme temperatures or pressures.

Born of Fire—The Igneous Family



The rock field in the smaller photograph was “born” from fiery molten rock, called **lava** (the large photograph). As the lava cools and hardens, recognizable characteristics, such as gas bubbles, are left in the new rock. These characteristics tell the history of the rock’s origins. So, even if you pack it up and take it home, that rock has a story it can tell.



Turn to page 361 of the textbook and read “Igneous Rock” for an introduction to the first rock family—those “born of fire.”

1. Define the following terms:

- *igneous rock*
- *lava*
- *magma*
- *extrusive rock*
- *intrusive rock*

It is a good idea to copy the summary diagram in Figure 5.8 below the definitions.

2. a. Think about it! Who is bigger: a puppy or a dog, a kitten or a cat, a baby or an adult human? Who had longer to grow?
- b. Now, write a prediction about the relationship between the length of the growth period and size.



Compare your responses with those in the Appendix, page 97.

Now it's time to get ready for the next investigation. It looks at the relationship between the speed at which molten rock cools and the size of the crystals formed. Write a hypothesis about this in your notebook. You will be using this hypothesis soon. Do not forget to back up your prediction with your reasoning.

Wouldn't it be great to be able to grow your own crystals? Especially if you could grow them large enough to create your own gems! Well, you can. It is highly unlikely, though, that you will end up with precious gems. Very special conditions must exist in nature for mineral crystals to grow. Many factors affect the size, colour, and final growth form of crystals. Remember that the growth form is the way the crystalline structure of the pure structure is assembled (put together) on a macroscopic (naked eye) level.



In the next investigation you will study the effects of temperature on crystal growth.

Investigation 5-B Cool Crystals, Hot Gems!



Refer to the investigation on pages 362 and 363 of the textbook. Read the introductory paragraphs and "Question." You have already written a hypothesis. Now, read the rest of the procedure.

The following photographs show the investigation in progress. Notice that the test tubes are in Styrofoam™ cups inside beakers. The beakers provide stability. The cups provide insulation. The test tubes were examined regularly. The most significant observations are shown.

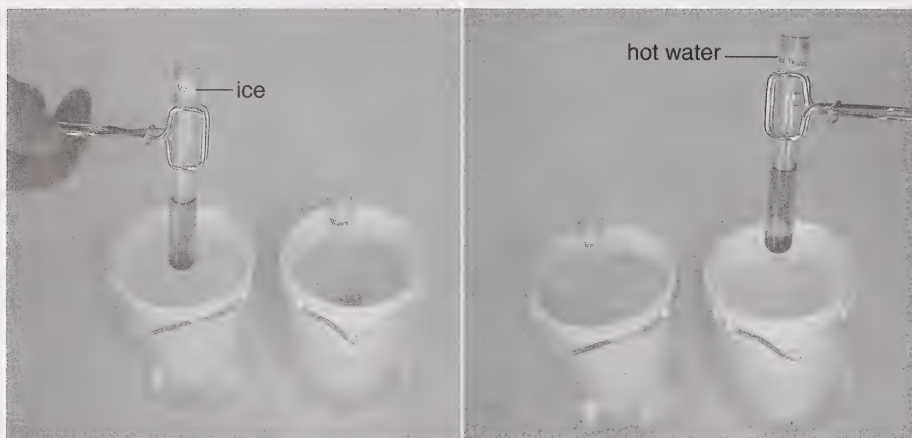
This picture was taken after Step 6 of the procedure.



The ice will cool the solution quickly.

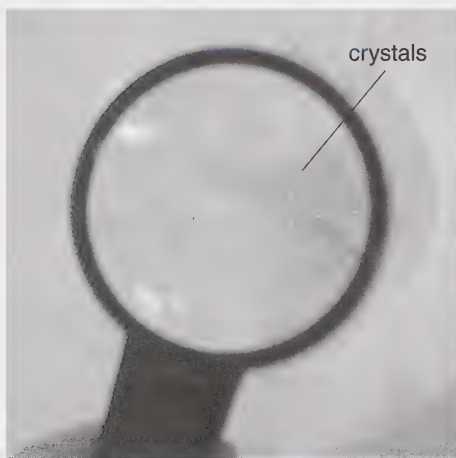
The hot (warm) water will let the solution cool slowly.

One hour later, the solutions were checked for crystals.

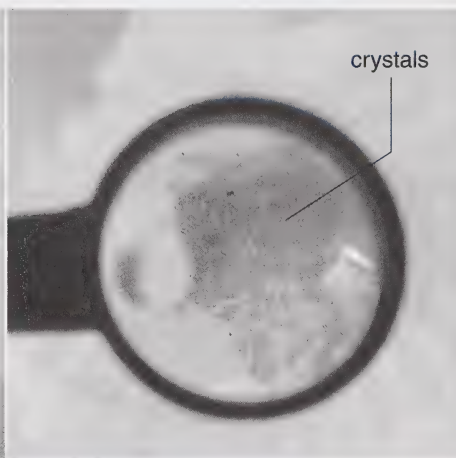


The next day, the contents of the test tubes were poured onto filter paper. This is a change from the procedure. Filter paper is much easier to find than a watch glass.

Ice Test Tube



Hot Water Test Tube



3. Answer the following on page 363 of the textbook.

- a. questions 1, 4, and 5 of “Analyze”
- b. questions 6 to 9 of “Conclude and Apply”

Check your responses with your teacher or home instructor.

end of investigation



Dumped or Deposited—The Sedimentary Family

The sedimentary family of rocks has a varied history. Many are made of rock particles dumped by wind, water, or ice. The particles were piled, compacted, and cemented together. Others grew from minerals dissolved by water. The minerals were deposited when the water cooled or evaporated. A third group is composed of plant material. They formed from the remains of plants covered by dirt. The plants broke down into a simple form, resulting in rocks that are very high in carbon.



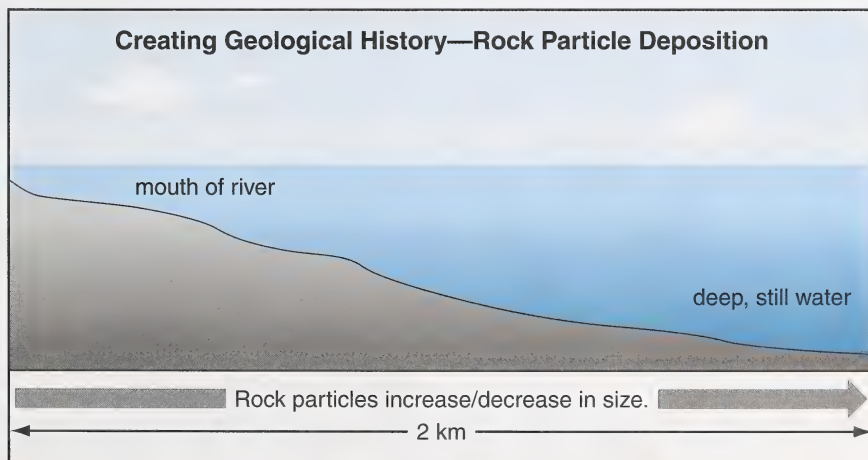
Find out a few more of the details as you read about sedimentary rocks on pages 364 and 365 of the textbook.

4. Write definitions for the following terms:

- *sedimentary rock*
- *sediment*
- *stratification*
- *compaction*
- *cementation*

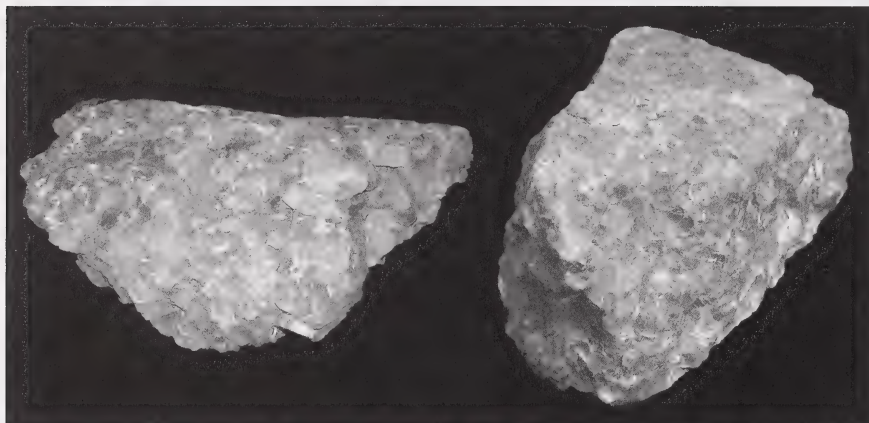
Note: It is important to realize that the particles (chunks) of rock found in sedimentary rock can vary in size from several centimetres to microscopic grains.

5. The faster water flows, the larger the rock particles it can carry. As a river enters a body of standing water, like a lake or ocean, the speed of the water decreases. Based on this information, copy and complete the following sketch. Draw rock particles of different sizes on the slope of the bottom of the lake. Predict changes in the particle size of the rock fragments. How do they differ at the mouth of the river and in the relatively still areas of the lake? Circle the correct term that completes the statement at the bottom of the sketch.



Compare your responses with those in the Appendix, pages 97 and 98.

Another type of sedimentary rock can form when water carrying dissolved minerals evaporates or cools. As water moves through Earth's crust, a variety of minerals dissolve into it. You have already been introduced to this concept in the soil module. Salinization occurs when water evaporates, leaving behind minerals, like halite (rock salt). If a large body of water dries up, large amounts of minerals can be deposited. The potash shown in the photograph is a type of salt. It is mined in Saskatchewan. It was deposited when an ancient sea that covered most of Alberta and Saskatchewan dried up.



6. a. Explain why the crystals in the potash rock on the left are much larger than the crystals in the one on the right.
- b. Pure potash crystals are clear and colourless. Suggest why much of this potash would have a reddish colour.
- c. Look closely at the potash crystals. Try to classify the crystal system of this mineral.



Compare your responses with those in the Appendix, page 98.



The stalactites and stalagmites (in the picture on the left) were formed in a way similar to the potash rocks. Water has dripped and evaporated in this cave for thousands of years. It has left minerals behind to build these neat formations.



A similar situation occurs when hot geothermal water reaches the surface. Remember, as particles lose energy, they move closer together. (The spaces between them get smaller.) Hot water from deep within Earth cools at the surface. The minerals dissolved in water particles are squeezed out and deposited as sedimentary rock. The picture on the right shows one example of a large sedimentary rock basin. It is one kind of formation made by this type of sedimentary rock deposition.

You may have guessed by now that sedimentary rocks can be formed in three different ways:

- (1) Clastic sedimentary rocks are formed from rock particles. They are deposited by wind, water, ice, or gravity; then they are compacted and/or cemented.
- (2) Chemical sedimentary rocks are created as cooling or evaporating water deposits dissolved minerals.
- (3) Organic sedimentary rocks are formed from the bodies or shells of organisms and the remains of plants.

It is interesting to note that limestone can be formed by any of these three methods.





Geologists use many methods to identify or describe sedimentary rocks. The method of formation—clastic, chemical, or organic—is their first clue. A second clue is the size of the rock particles (grains) in clastic rocks. The chemical composition (the minerals or elements in the rock) is a clue for chemical or organic rocks. A third clue for identifying sedimentary rocks is the presence of fossils. All three types of sedimentary rocks can contain fossils. With few exceptions, only sedimentary rocks contain fossils. This makes fossils an excellent clue for identifying a rock as a sedimentary rock. You will learn more about fossils later in this module.

Going Further



You already know that coal is a valuable Alberta rock because it is a fossil fuel. Find out about two other economically important rocks. Read “Did You Know?” on page 365 of the textbook. Use one of the Internet’s search engines to find out more about these rocks.

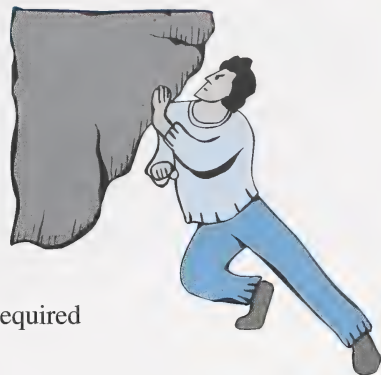


meta: to change

morph: shape or form

Under Intense Heat and Pressure—The Metamorphic Family

Rock, any rock, can change form when subjected to intense heat or pressure. Have you ever tried to move a large rock? No matter how much pressure (force per unit area) you apply, it is pretty much impossible.

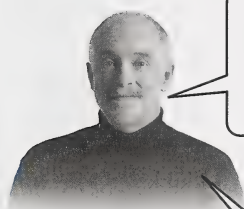


But geological forces fold and fracture immense areas of rock into mountains and valleys. (You will learn more about these movements later in the module.) Can you imagine the amount of pressure required to move and bend vast stretches of rock?

Did you know that when you squeeze snow, the pressure pushes the particles closer together? That's how making snowballs works. Increased friction between the particles produces heat and the snowball becomes an ice ball. The snow changes form due to an increase in heat energy caused by an increase in pressure.

A similar process occurs in rock, except the intense pressures are caused by movements in Earth's crust. The rock changes form. Pressure produces enough heat to free the mineral particles. This allows them to move (migrate) or reorganize into a different form. The rock does not melt!

Another way rock can change form is through exposure to magma's intense heat. Heat can be transferred from the molten rock to the solid rock around it. Changes in form can take place without actually melting the solid rock.



Look back at Figure 5.8 on page 361 of the textbook. Guess what kind of rock has formed all the way around the igneous intrusive rock.



It's metamorphic rock.

That's right!

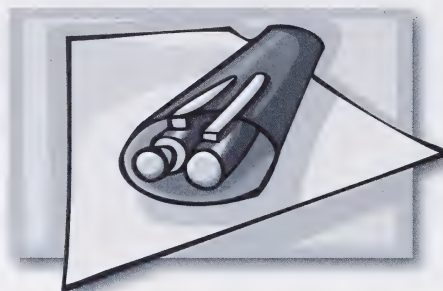


Turn to pages 366 and 367 of the textbook and read “Metamorphic Rock.” Here more information is given on the effects of intense heat and/or pressure on rock.

7. Define *metamorphic rock* and *parent rock*.
8. List three parent rocks and their corresponding metamorphic rock.



Compare your responses with those in the Appendix, page 98.



Turn to page 2 of Assignment Booklet 5A and answer question 2.

Going Further



Are you planning on doing the major project for this unit? If you are, don't miss “Looking Ahead” on page 366 of the textbook.

Summarizing Family Traits



Does each pair above belong to the same family? How can you tell? Identifying family members can be easy sometimes and extremely difficult other times. You have to look at a variety of traits or characteristics: hair, eye, and skin colour; the shape and size of facial features; height; body build; and anything else that is fairly distinctive. Identifying rock families (and rocks) is a similar process.

9. Copy and complete the following table. Create a summary of the characteristics of the igneous, sedimentary, or metamorphic families. Place a check mark (✓) in the family cell or cells to which the characteristic would generally apply.

Rock Family Summary				
Characteristic	Family			
	Metamorphic	Sedimentary	Igneous	
			Intrusive	Extrusive
crystals easily visible				
randomly arranged crystals				
aligned, flattened, or banded minerals/ crystals (organized, non-random)				
rock particles or grains visible				
no grains or crystals visible				
fossils present				
bubbly or glass-like				
rock particles/grains stratified into layers of different colour or particle size				



Check your response with your teacher or home instructor.

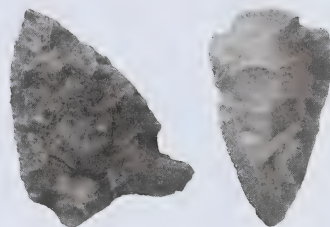
Scientific classification of rocks requires knowledge, practice, and special identification techniques. However, amateurs easily identify many common rocks and minerals. You may not be able to decide on a complete classification, but it is likely that you can find enough clues to guess the rock's family. Maybe you will find a little of the rock's history and make-up.

The next activity challenges you to look closely at rocks in your area or your personal rock collections. You will try to identify these rocks as igneous, sedimentary, or metamorphic rocks based on a variety of clues.

Find Out Activity Rock Identification



Read “Techniques for Identifying Rocks” on page 369 of the textbook. Review the information and photographs for each of the three families of rocks. A rock identification book or guide would be very helpful and would allow you to actually name some of your rock samples.



If you do not already have a rock collection, find some samples. Take a walk in a nearby, natural area or check a back alley, railroad, garden, or nearby gravel road. You may also look at decorative rocks used for landscaping. Consider using the rocks on the floors or walls of buildings. Once you have several distinctive rocks picked out, identify them to the best of your ability. Remember, you may need to observe a clean or fresh surface.

Note: It is a good idea to use a fresh page and turn it sideways so the columns can be larger. Be sure to plan ahead so the sizes of the cells are appropriate for the information they will contain.

10. Create a data table to help you classify rock samples. Under the heading “Characteristic” include the following:

- Which colours are present?
- Are crystals visible? If so, state the size and colour.
- Are rock particles/grains visible? If so, state the size and colour.
- Do mineral crystals appear at random?
- Are the minerals flattened, aligned, or grouped in bands?
- Are the grains sorted into layers?
- Are fossils present?
- Are there any other characteristics?
- Which family does the sample belong to?

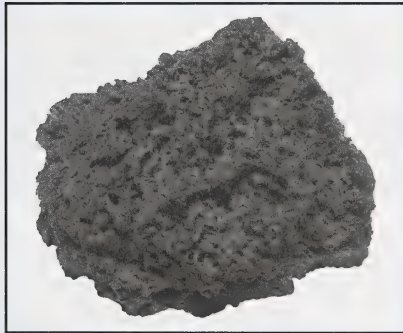
Try to classify at least five different rocks to at least their family. Other observations could include taste, smell, response to acid or magnet, cleavage or fracture, density, texture, and solubility in water.

11. Now that you have had some practice, list all the significant characteristics of each of the following rocks. Try to identify their family or families based on their characteristics. Include an extrusive/intrusive classification for any rock you believe to be of igneous classification. Also, include a clastic, chemical, or organic classification for any rock you believe to be sedimentary.

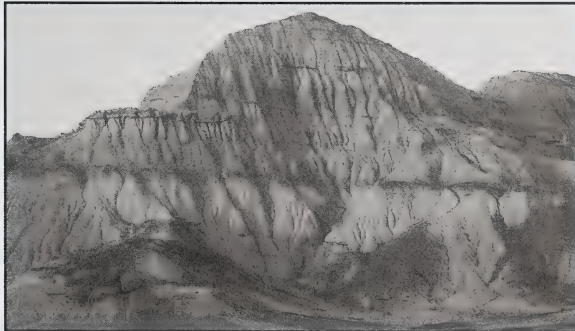
a.



b.



c.

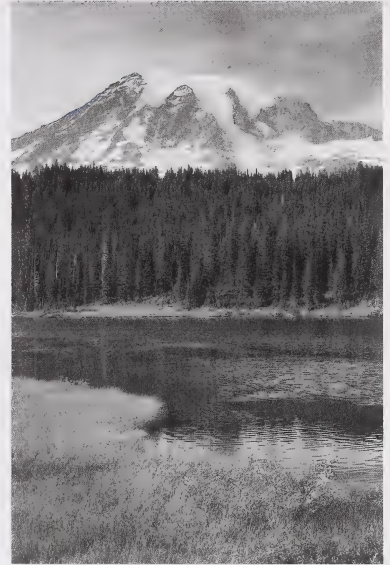


Check your responses with your teacher or home instructor.

Interrelating—The Rock Cycle

Rock families share many similarities: mineral components being the major one. Now, use your imagination. If an igneous rock was broken into pieces, deposited by gravity, and then compacted and cemented over millions of years, what would it be? A sedimentary rock is placed under intense pressure during a mountain-building process. Its minerals reorganize, flatten, and align themselves at right angles to the pressure. Is it still a sedimentary rock?

Did you realize that the igneous rock had become a sedimentary rock? Did you also realize that the sedimentary rock had then become a metamorphic rock? These changes are part of the rock cycle. Like water and carbon, minerals also cycle. As they change, the face of Earth changes with them. Mountains rise and fall; lakes become land; and molten rock hardens into an island in the middle of the ocean. The cycle of geological change never ends.



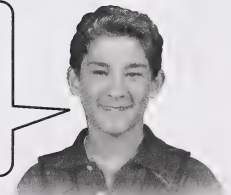
Turn to page 368 of the textbook and read “The Rock Cycle.”

12. Define *rock cycle*.
13. How many processes link the three families of rocks?



Compare your responses with those in the Appendix, page 99.

You should copy Figure 5.19 into your notebook. I did. I used a similar colour scheme to identify the processes of change. I also added “and solidification/crystallization” to the label on the left side of the arrow pointing from magma to igneous rock.



Sediments and Soil

You just investigated the heat-rock connection. Now, you will look at the soil-rock connection. You were introduced to soil in Science 7: Module 2, Plants for Food and Fibre. Soil is a mixture of organic and inorganic material. The inorganic parent material is a collection of rock particles that form the base of soil. Humus is the decaying collection of plant and animal remains that holds the nutrients and water that are so important for living plants.



From the rock cycle, you know that rock is weathered, eroded, and deposited as sediments that can be compacted and/or cemented into sedimentary rock. Do you wonder where soil fits into the rock cycle? Does it fit into the cycle?



Read “Sediments and Soil” and “Soil Profiles” on pages 371 and 372 of the textbook. You will review and add to your knowledge of soil formation and find out how it fits into the rock cycle.

14. Write definitions for the following terms:

- | | | |
|-------------------|-----------------------|------------------|
| • <i>compost</i> | • <i>fertile</i> | • <i>humus</i> |
| • <i>leaching</i> | • <i>soil profile</i> | • <i>topsoil</i> |

15. Use labelled sketches to illustrate the change from weathered rock to mature soil.



Compare your responses with those in the Appendix, page 99.

You have now completed the new concepts for this lesson. To review what you studied, answer the following questions.



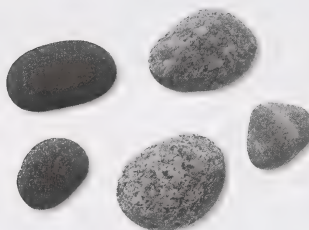
16. Answer questions 1 to 6 of “Topic 2 Review” on page 372 of the textbook.



Check your responses with your teacher or home instructor.

Looking Back

When you picked your souvenir rock, did you think about interrupting a cycle? Probably not. Rocks are thought of as unchanging and everlasting; but, as you found out, they're not. The rate of change is deceptive. People only notice catastrophic changes, like landslides, earthquakes, and volcanic eruptions. Changes in rocks usually occur at a very slow rate and go unnoticed. You removed your specimen rock from its location. You removed it from its natural cycle, at least temporarily.



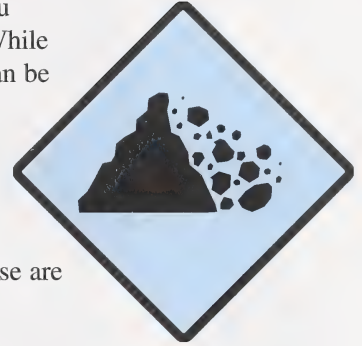
In this lesson you studied the classification of rocks according to their origin and the continuous evolution of rocks within the rock cycle. You investigated the role the rate of cooling has on crystal formation and how mineral content helps to identify rocks. In the next lesson you will look at certain phases of the rock cycle in greater detail.



Turn to page 2 of Assignment Booklet 5A and answer questions 3 and 4.

Lesson 3: Erosion

Have you ever travelled through the mountains? If you have, did you notice signs like the one on the right? While the road is usually clear, these “falling rocks” signs can be lifesavers in the early spring or after a heavy rainfall. Why these periods in particular? Closer to home, you may have noticed similar events first-hand. Has water from the eaves washed out a flowerbed or part of the lawn? Have you experienced the discomfort of rock particles stinging your face on a windy day? These are examples of erosion in action.



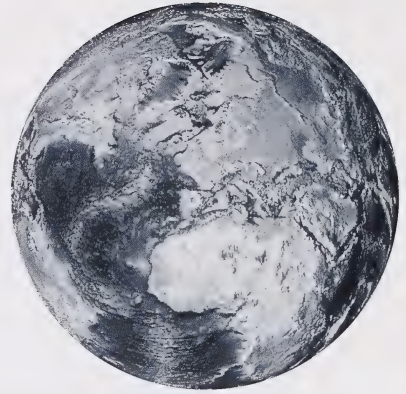
In this lesson you will study the mechanisms of erosion. Mechanisms that, bit by bit, can reduce mountains to rubble and change the face of Earth.

Weathering



Since the beginning of time, humans have chipped away at rocks. They used the rock to build homes, monuments, and a wide variety of other things. Dynamite, bulldozers, and dump trucks have greatly increased the speed at which humans can break down and transport rocks. But humans have a major competitor in these endeavours—Mother Nature. Natural forces make large and small, sudden and gradual changes to Earth’s crust. Often, these natural changes begin with **weathering**.

The surface of Earth is broken down (weathered) by chemical and mechanical means. The agents responsible for this process may be organic or inorganic. Organic agents include plants and other organisms. Inorganic agents include water, wind, ice, and acids. Organic or biological weathering can be either chemical or mechanical. Chemical weathering includes secretion of acids that dissolve rocks. Mechanical weathering includes roots growing and breaking up rock.



For more details on weathering agents and processes, read the introductory paragraphs of “Topic 3: Erosion” on pages 373 and 374 of the textbook.

1. Write definitions for the following terms:

- *weathering*
- *mechanical weathering*
- *frost (ice) wedging*
- *chemical weathering*
- *biological weathering*

2. Electricity can be generated using coal as a fuel source. Explain how this can cause serious damage to buildings and statues.
3. In Module 1 you were introduced to lichens. A lichen is a fungus living in a symbiotic relationship with an algae. This is a mutually beneficial relationship. The algae produce food through photosynthesis. The fungus supplies nutrients obtained from the rock the lichen grows on. Identify, as specifically as possible, the weathering process the fungus must use to achieve this.



Compare your responses with those in the Appendix, page 100.

You are aware that the acid test can be used to help identify minerals. Rocks are composed of minerals. So, you can use an acid test to help you identify rocks. The next investigation gives you the opportunity to try this technique. It also challenges you to identify rocks that are susceptible to chemical weathering by acid rain.

Investigation 5-D Rocks That Fizz

A bit of background information can make this investigation more interesting and informative.



Some rocks will fizz when acid is dropped on them. These rocks are formed from reactive minerals, or they are cemented together by one of these minerals. For example, limestone is mostly composed of the mineral calcite. Calcite's chemical name is calcium carbonate. Calcium carbonate readily reacts with acid. Organic limestones form from the shells and skeletons of oceanic creatures (corals, shellfish, and plankton). These organisms remove calcium carbonate from the water to build their shells. Guess what happens when you drop acid onto weathered shells?

Some minerals react with cold and/or dilute acid; some react with hot and/or concentrated acid.

Refer to the investigation on page 375 of the textbook.

If you have access to hydrochloric acid, perform the investigation as outlined in the textbook under the direct supervision of your home instructor. Modify the equipment and materials as necessary to fit your situation. Most of the named rocks can be obtained in small chunks from a landscaping or garden centre.

Pay special attention to the safety precautions listed in the textbook.

If you do not have access to hydrochloric acid, talk to your teacher or home instructor. If you haven't tried the acid test, get a calcium-based antacid tablet or a piece of chalk. Scrape it with a dull knife and add vinegar to the powder.

4. Answer the following on page 375 of the textbook.

- questions 1 and 2 of "Analyze"
- questions 3, 4, and 5 of "Conclude and Apply"
- question 6 of "Extend Your Skills"



Compare your responses with those in the Appendix, page 100.

end of investigation

Erosion—Transporting Rock Materials



Look closely at these pictures. Do you think the boulders in the one on the left were always smooth and round? Does it look like the stream in the picture on the right was always there? Weathering is the process responsible for breaking off the corners of rocks and carving that stream. But there is something missing here. The rock particles that formed the ridges and filled that space in the plain are gone. A second, very closely related process is responsible for removing the missing material. That process is called **erosion**.



Turn to pages 376 to 378 of the textbook and read “The Changing Surface of Earth” and “Water in Motion.” Weathering and erosion often occur at the same time. Water dissolves the rock and carries it away. Gravity moves a rock down a slope as it breaks loose. The term *erosion* is often used to encompass both processes.

5. Define the terms *erosion* and *abrasion*.
6. List the agents of erosion.
7. Look at the pictures at the bottom of page 378 of the textbook. Is the riverbed in the photograph on the left young or mature? Explain.



Compare your responses with those in the Appendix, pages 100 and 101.

Going Further



Some of the results of weathering and erosion rival the work of sculptors. Others look more like the result of someone's temper tantrum. "Investigation 5-E: Nature's Design" on page 379 of the textbook gives you a chance to be creative, artistic, and scientific. Refer to the investigation on page 379 to find out more.

To test your understanding of the concepts in this lesson, answer the following questions.



8. Answer questions 2, 3, and 4 of "Topic 3 Review" on page 380 of the textbook.



Compare your responses with those in the Appendix, page 101.

Looking Back

Falling rock is a victim of weathering and erosion. The agents discussed here don't work quickly; but, over time, they can reduce a mountain to rubble and wash it to the sea.

In this lesson you explored the various mechanisms of weathering and erosion and identified some of the results of these processes.

Section 1 Review



To review the concepts covered in this section, answer the following “Wrap-up: Topics 1–3” questions on page 381 of the textbook.



1. Answer question 1 of “Reviewing Key Terms.”
2. Answer questions 2 to 10 of “Understanding Key Concepts.”



Check your responses with your teacher or home instructor.

Conclusion



Can you tell a longer tale? Do these landscapes provide more information to your more focused eye?

In this section you investigated the properties of minerals and rocks. You learned how to identify rocks using these properties. You explored the processes that include minerals in rocks and the processes that form rocks. You also studied the mechanisms responsible for the continuous changing of Earth’s surface.



Turn to pages 3 and 4 of Assignment Booklet 5A and answer questions 5, 6, and 7.

Section 2

Earth's Changing Face

Have you cut your finger, your knee, or anything else before? Sure it bleeds at first; but after a while, the bleeding stops. Your body had started healing itself. (The process of blood clotting is a fascinating study in itself.) Your skin is the outer protective layer of your body. Just think of all of the things it keeps out and keeps in, for that matter. Earth's crust is very much like your skin. It's relatively thin, it slides over parts underneath; and it is forever changing. One difference, though, is the rate of change. Most geologic processes take a very long time and their cause is hidden from view inside the planet.

In this section you will investigate the relationship between the features of Earth's crust and what is beneath it.



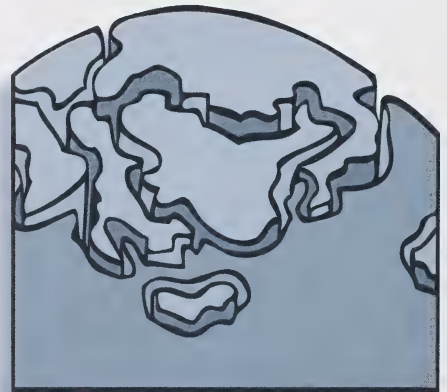
Lesson 1: The Moving Crust



Picture each continent in the map as a separate puzzle piece. Do you suppose there is a reasonable fit between Africa and South America? If so, does this mean Africa and South America were once connected? If this is true, why are they so far apart now? How can the continents move so far away from each other?

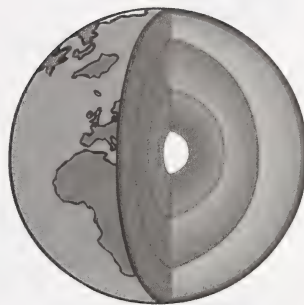
This was exactly what Alfred Wegener tried to solve. Earth's land masses had to have been in different places and in contact with one another in the past. Wegener had a lot of evidence: geologic features, fossil records, and meteorological information. What he could not explain is how they separated and moved to their current positions. What mechanism provided the tremendous forces required to move the land masses across the surface of Earth? His inability to explain this kept his theory of continental drift from being accepted until twenty years after his death.

In this lesson you will examine the evidence gathered by Wegener. You will see how technological advances helped to gather further supporting evidence. All of this led to the theory of plate tectonics.



Inside Earth

Exactly what lies beneath your feet? Old cartoons showed people digging through the centre of Earth and emerging on the other side. Humans knew little of the conditions and processes in the interior of Earth. They only had volcanic eruptions and earthquakes as clues. Early miners found that temperature increased the further they went down. Lava spewing from volcanoes hinted that Earth's interior was very hot and molten. Details of the interior were hidden until better technologies were developed.



Over the years, scientists have used clues from a wide variety of sources to piece together a picture of the world beneath your feet. Turn to page 382 of the textbook and read the introductory paragraph of “Topic 4: The Moving Crust.” You will be introduced to the current model of Earth's interior.

1. Define for the terms *mantle*, *outer core*, and *inner core*.
2. In your notebook, create a large copy of the illustration in Figure 5.35. Add labels to your diagram showing some of the information of each layer. Title your diagram “Model of Earth's Interior.”



Compare your responses with those in the Appendix, page 102.

Evidence for Continental Drift

It took centuries for cartographers to produce reliable maps of the world. Until then, the puzzle-like fit of the continents could not be recognized. Once reasonable maps were available, the pattern became a scientific mystery. Alfred Wegener, a twentieth-century scientist, tried to solve this mystery. He collected evidence to support his notion. He believed that the continents were once in different locations.

At the time, scientists believed that parts of continents might move very slowly up and down to build mountains. They suggested that folded mountain formations were the result of Earth shrinking. Earth's interior cooled, causing the crust to wrinkle, like the skin of a dried apple. The idea of huge islands of rock moving across Earth's surface was hard for them to accept. They had little knowledge of Earth's interior. Scientists, including Wegener, could not see a way for such major crustal movements. So, they rejected Wegener's theory of continental drift.



Turn to pages 383 to 385 of the textbook and read about all of the evidence gathered by Wegener and the scientific community's response to his hypothesis.

3. Describe two examples of fossil evidence that supported continental drift.
4. How did the scientific community try to explain Wegener's biological evidence without accepting continental drift?



Compare your responses with those in the Appendix, page 102.



Going Further

Wegener died a ridiculed man. Years later, modern technologies showed how the crust could be moved. Wegener's ideas were revived. Find out more about the man and his ideas. Do "Internet Connect" on page 385 of the textbook.



Imagine each continent as a piece of a giant jigsaw puzzle. Can you use the clues to put it all together? Show how it was 200 million years ago. In the next activity you will piece the supercontinent, Pangaea, back together. You will use the biological and geological evidence gathered by Wegener to help you.



Investigation 5-F Give Me a Clue!

Refer to the activity on page 386 of the textbook.

Use the following map to complete this investigation. It is provided at the back of the Appendix.

Once you get the map, follow the steps of the procedure.



5. Answer the following on page 386 of the textbook.
 - a. questions 1 and 2 of “Analyze”
 - b. question 3 of “Conclude and Apply”

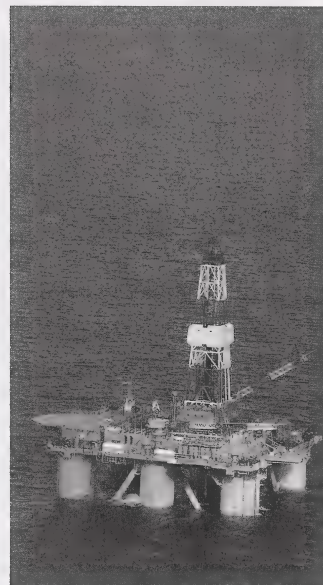


Compare your responses with those in the Appendix, page 102.

end of investigation

Advances in Technology

Scientists have often wished for better equipment. Technological developments have yielded improvements in the precision and variety of scientific instruments. This has led to a better understanding of Earth's interior and crust. The new evidence supported Wegener's hypothesis. A second, more advanced crustal-movement theory was developed.

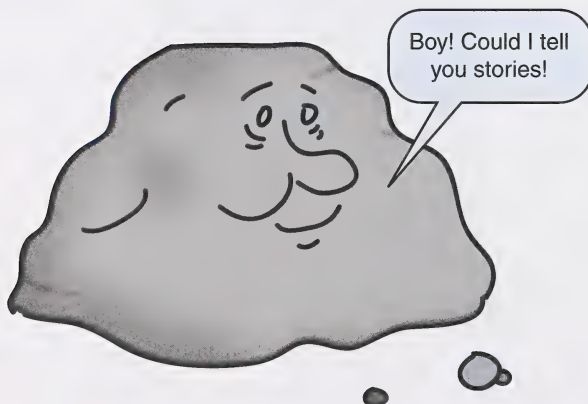


Turn to pages 387 to 389 of the textbook and read “Advances in Technology” and “Deep Sea Drilling.” Four technologies will be discussed. They contributed to a better understanding of Earth's crust below the oceans.

6. Write definitions for the terms *sonar* and the *theory of seafloor spreading*.
7. At what rate is the Atlantic Ocean floor spreading?



Compare your responses with those in the Appendix, page 103.



Isn't it amazing the things that rocks can tell you? Just think, you are only scratching the surface of the information they can provide. In the next activity you get to interpret a little of the data yourself. The activity also illustrates how data can be displayed for easy interpretation.



Find Out Activity What Do the Rocks Tell Us?

Read the entire activity on page 388 of the textbook.

8. a. Answer questions 1, 2, and 3 of “Procedure.”
- b. Answer “What Did You Find Out?”



Check your responses with your teacher or home instructor.



Okay, here’s a little test. What do these pictures represent? Do you need some clues? Well, think technologies—technologies used to learn about the sea floor and sea floor spreading. That’s right, sonar and the magnetic reversals discovered using magnetometers! In the next activity you are going “low tech.” You will develop, and then interpret, a simple model that demonstrates sea floor spreading.



Find Out Activity The Spreading Sea Floor

Read the entire activity on page 389 of the textbook. Then carry out the steps of the procedure.

9. Answer questions 1, 2, and 3 of “What Did You Find Out?”



Compare your responses with those in the Appendix, page 103.

Plate Tectonics

Did you know that Earth has plates? No, not the kind you eat on. Earth's crust actually resembles a huge cracked eggshell. What's even more amazing is that these huge chunks, or **plates**, are in motion! When exploration of the ocean floors revealed a series of rifts and ridges, it confirmed that Earth's crust was not static (stationary).



Turn to page 390 of the textbook and read about the **theory of plate tectonics**.

10. Write definitions for the following terms:

- *plate*
- *converging plates*
- *diverging plates*
- *theory of plate tectonics*

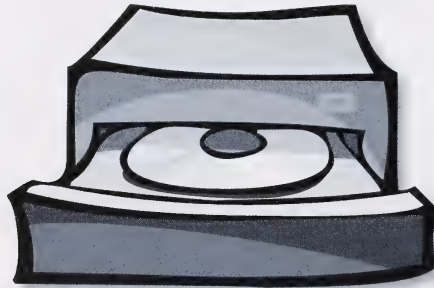
11. What did J. Tuzo Wilson suggest happens at some of the boundaries between plates?



Compare your responses with those in the Appendix, page 103.



For more information on plate tectonics, view the segment “Plate Tectonics” on the *Science 7 Multimedia CD*.



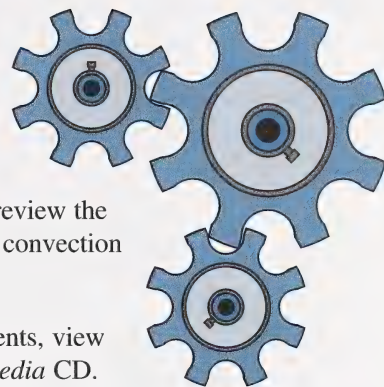
Going Further



Create your own model of plate tectonics. On page 391 of the textbook, follow the directions in “Investigation 5-G: Building a Model of Plate Tectonics.”

A Mechanism for Movement

Plate tectonics is a good theory based on a lot of good information. But Wegener's problem still hasn't been dealt with! How do you explain the movement of these humongous plates of crust?



Read about the force behind crustal movements on pages 392 to 394 of the textbook. If necessary, review the particle model of matter and the information about convection currents in Science 7: Module 3.

To reinforce your understanding of crustal movements, view the segment "Subduction" on the *Science 7 Multimedia* CD.

12. Write a definition for the term *subduction zone*.
13. What happens when the following occurs?
 - a. continental plates converge
 - b. a heavier (made from denser rock) oceanic plate and a lighter (made from less dense rock) continental plate converge
 - c. oceanic plates converge
 - d. oceanic plates diverge
 - e. continental plates diverge



Compare your responses with those in the Appendix, page 103.

You have now completed the new concepts for this lesson. To review what you covered, do the following questions.



14. Answer questions 1, 2, 3, 4, and 6 of "Topic 4 Review" on page 394 of the textbook.

Check your responses with your teacher or home instructor.

Looking Back

Are the pieces of the puzzles beginning to fall into place? Would you now believe that Edmonton was once located south of the equator? Are you beginning to see how Alberta could have been covered in lush tropical forests and swamps?

Bit by bit and piece by piece, the history of Earth is coming together. In this lesson you studied how scientists turn accumulated knowledge into current theory. You discovered how technological advances played a big role in developing the theory of plate tectonics.



Turn to pages 5 and 6 of Assignment Booklet 5A and answer questions 1, 2, and 3.

Lesson 2: Earthquakes



Here is a peaceful scene in the Canadian Rockies. The Sun is beginning to peak over the quiet mountains and the still lake. In a moment, a catastrophic change could rock this area, leaving it forever altered.

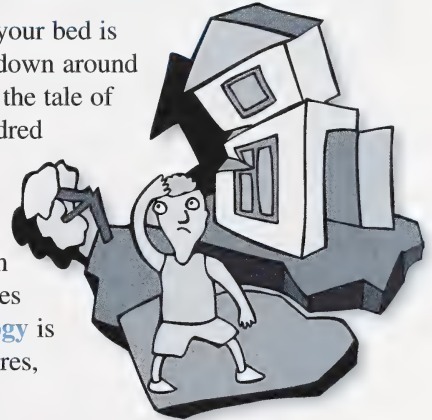
In Lesson 1 you studied the theory of plate tectonics. You saw that this theory is supported by wide variety of evidence. It explains that Earth's crust is very mobile. Earthquakes provide very visible proof that Earth's crust moves. As you can imagine, the boundaries where plates slide past or under one another are not very smooth. You have jagged rock pushing against jagged rock. There are billions of tonnes of solid crust. The pressures trying to move them in different directions are unimaginable. Movement can occur as a series of small slips over many years. Or tension can build over hundreds of years then release catastrophically in a few seconds.

Have you experienced, or seen someone, trying to open a stuck drawer? It does not budge, so you try harder, and wham! The drawer flies open and everything ends up on the floor. It's a minor mishap, but very similar to what occurs at plate boundaries and faults in Earth's crust.

In this lesson you will investigate how earthquakes are detected and monitored. You will also examine how the characteristics of an earthquake are inferred from data.

Detecting and Measuring Earthquakes

Imagine the terror of suddenly waking up and your bed is rolling and jolting. There are objects crashing down around you and on top of you. Many have lived to tell the tale of similar realities; many have also died. Six hundred thousand people died in a single earthquake in China in 1976. Each year, the economic costs of earthquake-related destruction runs into the billions. The potential for death and destruction makes understanding and predicting earthquakes a priority in many parts of the world. **Seismology** is the field of science that studies, detects, measures, and predicts earthquakes.



Read the introductory paragraphs of “Topic 5: Earthquakes” on page 395 of the textbook. Then turn to pages 396 and 397 and read “Measuring Earthquakes” and “Earthquake Waves.”

1. Write definitions for the following terms:

- *seismograph*
- *bedrock*
- *Richter scale*
- *seismic wave*
- *aftershock*

2. Explain why a seismograph must be attached to bedrock.



Compare your responses with those in the Appendix, page 104.

The following activity will challenge you to design and build a seismograph.



Find Out Activity Shake It!

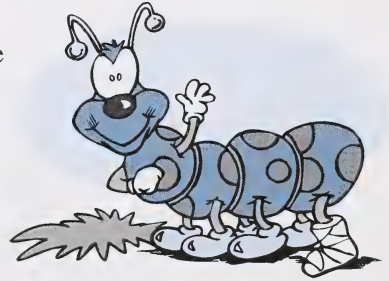
Read the entire activity on page 397 of the textbook.

Before you begin your design, you may want to research seismographs at the library or on the Internet. If you are working alone, you should discuss your design with your teacher or home instructor. You don't have to build a working seismograph.



Earthquake Waves

When you wave, your hand presses against the air. Kinetic energy is transferred from your hand to the air. The air is compressed and forced to move away from your hand. You can detect the movement of the air in several ways. You can feel the sensations it produces as it moves against your skin. You can also see the movement of light objects hit by the waves of air.



Similarly, earthquakes transfer energy outward from their point of origin (their **focus**). They compress and move Earth's crust and human-made structures. Earthquake waves can be detected and monitored in a variety of ways. You can feel the ground move under your feet, or you can use extremely sensitive, high-tech devices.

Earthquakes are the result of stress release in Earth's crust and upper mantle. Rock formations under compression or tension suddenly fail. They release a great deal of energy. This energy is transmitted through the surrounding crust. It radiates in all directions from the seismic focus (the origin of the earthquake.) There are three kinds of waves with distinct characteristics. Seismologists use data gathered from these waves to determine the location and strength of the earthquake. They also use this information to make an educated guess as to the make-up of Earth's interior.



Turn to page 398 of the textbook and read “Types of Earthquake Waves.” One of the waves you will cover are surface waves. These waves are also known as L waves.

3. Define the term *focus*.
4. Refer to the seismogram in Figure 5.51. What feature do you think can be used to infer the magnitude (strength) of an earthquake?



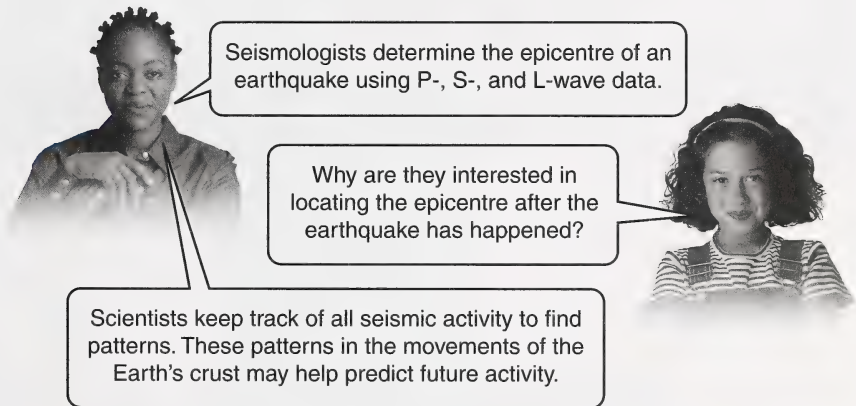
Compare your responses with those in the Appendix, page 104.

Finding the Epicentre of the Waves

Have you, or anyone you know, ever experienced an earthquake of any magnitude? Alberta is not a very active seismic zone, but the coast of British Columbia is. Can you suggest the reasons for this? Think back to your last lesson! Based on what you already know, can you identify areas where earthquakes are more likely to occur around the world?



Turn to page 399 of the textbook and read “Locating an Earthquake.”



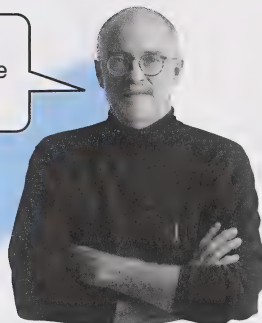
Knowing the areas of seismic activity helps engineers and architects plan suitable structures for an active region. For example, large dams are not suitable structures in locations that are prone to earthquakes.

5. Define *epicentre*.



Compare your response with the one in the Appendix, page 104.

In the next activity you will manipulate seismic data and use a graph to determine the epicentres of two earthquakes.



Investigation 5-H Locate the Epicentres

Refer to the investigation on pages 400 and 401 of the textbook. You may require the assistance of your teacher or home instructor for this investigation.

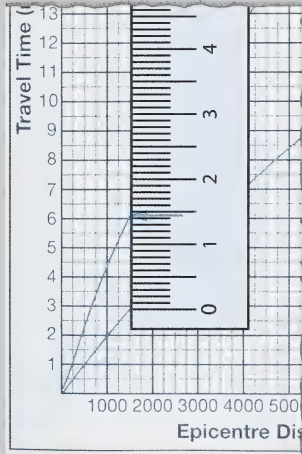
Part 1

6. a. Use “Time Travel Graph for P and S Waves” on page 401 to complete the following table.

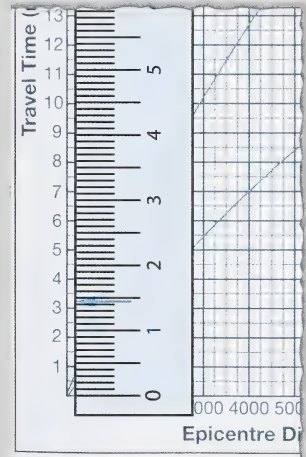
Distance (km)	Difference in Arrival Time
1500	3 min 10 s
2250	
2750	
3000	
4000	5 min 40 s
7000	
9000	

Note: To complete the data table, you need to find a time difference between the arrival of the P wave and the S wave. Here is one way to do it. It shows how the difference at a distance of 1500 km was determined. This procedure also shows why the value for 1500 km is different than the one on page 400 of the textbook.

step 1: Measure the vertical difference between the two graphs at 1500 km.



step 2: Place the zero mark of the ruler on the zero point of the Travel Time axis. Read the time at the measured distance.

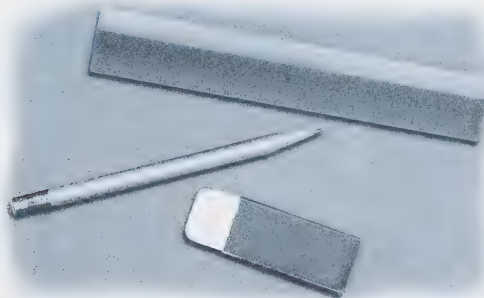


The time difference between the P wave and the S wave is about 3 min 10 s.

b. Answer questions 1 and 2 of “Analyze.”



Check your responses with your teacher or home instructor.

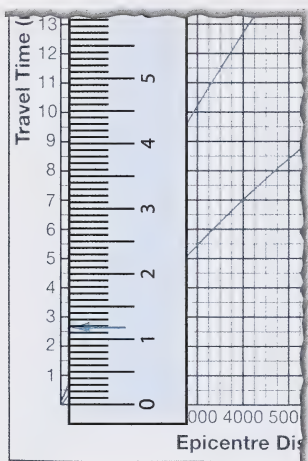


Part 2

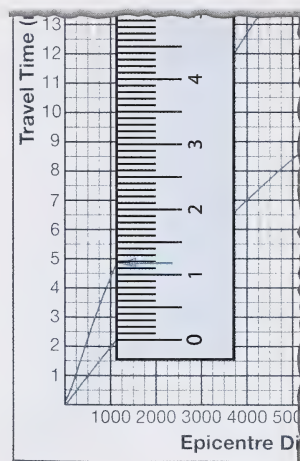
Read the entire procedure in Part 2.

For step 2 of the procedure, reverse the method used in Part 1. For example, to find the distance the Edmonton seismograph station was away from Earthquake A, follow these steps:

step 1: Place the zero mark of the ruler on the zero point of the Travel Time axis. Measure the time difference wanted (2 min 37 s).



step 2: Place the zero mark of the ruler on the P wave graph. Slide the zero mark along the graph until the distance between the graphs equals your measurement.

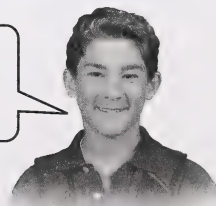


step 3: Read the epicentre distance. In this case, it is 1125 km away.

Earthquake A was about 1125 km away from the Edmonton seismic station.

For steps 3 to 5 of the procedure, you will use the map of Canada provided at the back of the Appendix. You will need it for the rest of this activity.

In step 3, the textbook refers to the distance Earthquake A is from St. John's. It should refer to Edmonton, not St. John's.



To locate the epicentre (steps 3 to 5), you need a compass. Draw a circle with the appropriate radius around each centre on the map you traced. For example, draw a circle with a scaled radius of 1125 km around Edmonton for Earthquake A.



Repeat this for at least three centres, as illustrated in the diagram.

7. a. Complete steps 2 to 5 of the procedure on page 400.
- b. Answer questions 1, 2, and 3 of “Analyze” on page 401.
- c. Answer questions 4 and 5 of “Conclude and Apply” on page 401.

Check your responses with your teacher or home instructor.

end of investigation

In the next investigation you will plot the location of a number of earthquake foci. You will use the information to infer tectonic features of the region.



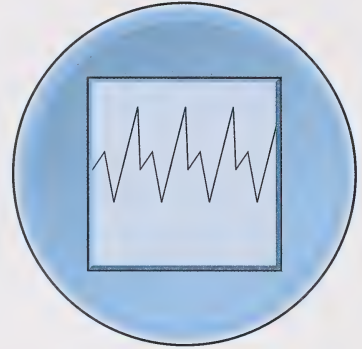
Investigation 5-I Plotting Earth's Movement



Refer to the investigation on page 402 of the textbook.

Read “Think About It.” Then do the following.

8. a. Carry out the steps of “What to Do.”
- b. Answer the questions 1 to 4 of “Analyze.”



Check your responses with your teacher or home instructor.



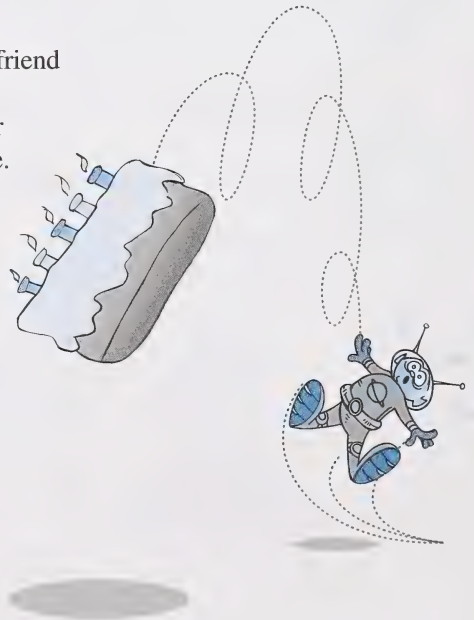
end of investigation



Read “Cool Tools” on page 401 of the textbook. How small a movement can the laser system detect?

Earthquake Zones

You are having a very weird dream! Your friend Xergo, the alien from another galaxy, has arrived. It is your birthday and your mother has prepared a delicious multi-layered cake. Xergo gets the honour of bringing it over and placing it before you. But Xergo is not yet accustomed to Earth's slight gravity. Xergo slips, the cake flies, then CRASH! The cake is subjected to “extreme” stresses. The top layers crack and slide away (on the whipped cream icing) to the floor. You make the best of a bad situation to explain fracture and faulting to your alien friend. Your dream fades with you and Xergo delving happily into the mystery and history of the movement of the layers.

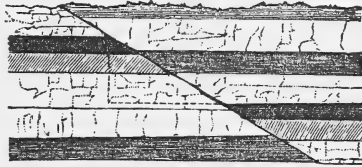


fault: a fracture in rock along which the adjacent rock surfaces are displaced in any plane



Like the cake, rock layers in Earth's crust are subjected to a variety of stresses. There are compressions, tensions, and temperatures. The layers respond to the magnitude and type of stress. Under extreme stress, rock can stretch, fold, fracture, or melt. When rock fractures (breaks) and moves along a fracture, a **fault** develops. Slippage along faults leads to earthquakes. There are many fault zones throughout Earth's crust. Some are the result of plate tectonics; others result from past earthquakes.

For more information about faults, view the segment "Transform Faults" on the *Science 7 Multimedia CD*.



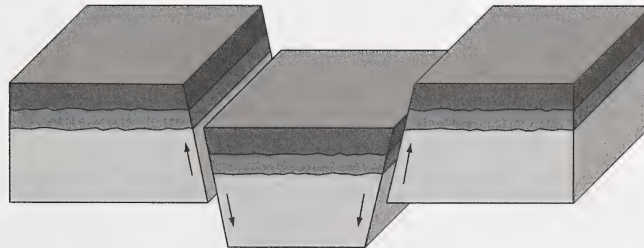
Turn to page 403 of the textbook and read "Earthquake Zones" and "Types of Rock Movement in Earthquakes."

9. Write definitions for the following terms. Sketch each type of fault with its definition.

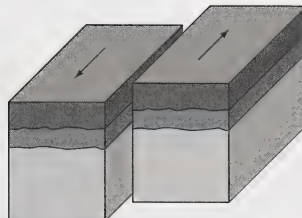
- *normal fault*
- *reverse (thrust) fault*
- *strike-slip or transform fault*

10. For each diagram given, identify the type of fault and whether it is due to tension, compression, or shearing.

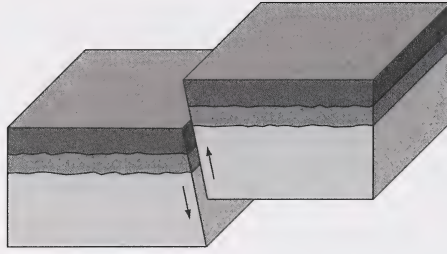
a.



b.



C.



11. Where are each of the three types of faults likely to occur?



Compare your responses with those in the Appendix, pages 104 and 105.

Find Out Activity Share Your Faults

This activity challenges you to construct a model illustrating the three types of faults found in Earth's crust.

Refer to the activity on page 404 of the textbook.

12. Follow the procedure. Have your home instructor approve the plan for your model(s) before you build it. Build your fault model(s), and explain to a friend or parent the kind of activity that occurs along fault lines.

Check your response with your teacher or home instructor.

Planning for a Big One!

Can you imagine what it must be like to have a building shake apart around you? Can anything be done to prevent or reduce damage and injury? If you live in an area prone to earthquakes, it is a good idea to think ahead. Architects and engineers have. They have designed structures with earthquakes in mind. Could you, as an individual, do anything to increase your safety and the safety of others?



Turn to page 404 of the textbook and read "Preparing for Earthquakes."



Find Out **Activity** Be Prepared!

Is a house on wheels an earthquake solution? If an earthquake rolled through, you and the house could simply roll along with it! Can you think of any problems with this solution? While working through this lesson, did you think about life in an earthquake zone? What changes would be necessary in your life if earthquakes were common where you live? This activity challenges you to consider that question.



Refer to the activity on page 404 in the textbook.



13. Follow the procedure. Discuss your list with your parents and a friend.

Check your response with your teacher or home instructor.

Other Effects of Earthquakes

tsunami: a giant wave created by an earthquake on the ocean floor

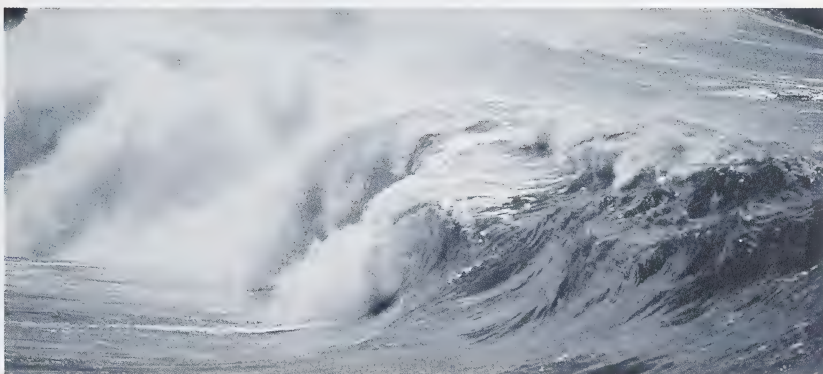
Doesn't the word **tsunami** alone give you an impression of power and devastation? Tsunamis can reach speeds of 800 km/h in the open sea and 240 km/h near land. At sea, these waves reach heights of less than 1 m, making them undetectable. The destructive power of a tsunami only becomes apparent as it reaches the shallow part of the coastline. A tsunami can rise to over 60 m in height in a matter of minutes. The first sign of the wave's approach is a drop in the water level. Then it comes crashing inland, destroying everything in its path.



Read page 405 of the textbook. Find out more about tsunamis and other equally devastating earthquake effects.



To learn more about tsunamis, try "Internet Connect" on page 405 of the textbook.



You have now completed the new concepts for this lesson. It's time to test your knowledge by doing these questions.



14. Answer questions 2 to 5 of “Topic 5 Review” on page 405 of the textbook.



Compare your responses with those in the Appendix, page 105.

Looking Back



In this lesson you investigated the causes of earthquakes. They are one of the very visible pieces of evidence that Earth’s crust is always on the move. You saw how earthquakes are caused and how they are monitored. In the next lesson you will study another visible piece of evidence of crustal activity—volcanoes.



Turn to pages 6 and 7 of Assignment Booklet 5A and answer questions 4, 5, and 6.

Lesson 3: Volcanoes

An erupting volcano is spectacular evidence of Earth's molten interior and its ever-changing crust. Billowing clouds of dust and ash, hurtling rocks, and fiery lava are fascinating. A volcano is also a dramatic example of sudden and catastrophic change in Earth's crust. Have you seen video clips or newspaper accounts of volcanic activity around the world? Where in Canada might a volcano erupt? Is there evidence of past or future volcanic activity anywhere in Canada? What conditions in Earth's crust lead to an eruption?

In this lesson you will examine patterns related to the location of earthquakes and volcanoes. These patterns also suggest a cause for earthquakes and volcanoes.



Volcanoes to Remember

What would you do if a hole opened on your street and molten lava began spewing out? A farmer in Mexico faced this dilemma in 1943. He shovelled vigorously, trying to fill the hole, but to no avail. By the next day, a 2-m crater had opened up and the volcanic activity had increased. Within a year, a volcanic cone 430 m high and almost 1 km in circumference had replaced his field and two small villages. In 1952, the 500-m Paricutin volcano suddenly went dormant.



Find out about other famous volcanoes that changed or ended the lives of many people. Read the introductory paragraphs of “Topic 6: Volcanoes” on page 406 of the textbook. Then continue reading “Famous Volcanoes” on page 407.

1. Write definitions for the terms *vent* and *dormant*.
2. Heavier ocean plates often subduct under lighter continental plates. It is not uncommon for volcanic mountains to arise about 100 km inland from an oceanic trench. Explain this phenomenon.



Compare your responses with those in the Appendix, page 106.

Could your home one day be engulfed by a volcano? It would be handy to know so you can plan ahead. In the next investigation you will pinpoint earthquake and volcano locations around the world. You will try to identify patterns.



Investigation 5-J Patterns in Earthquake and Volcano Locations



Read the entire investigation on pages 408 and 409 of the textbook.

Get the map for this investigation from the back of the Appendix. Study the map very carefully.

3. Answer the following on page 409 of the textbook.
 - a. questions 1 to 5 of "Analyze"
 - b. questions 6 and 7 of "Conclude and Apply"



Compare your responses with those in the Appendix, page 106.

end of investigation

Going Further



Do the activity suggested in question 8 of "Extend Your Knowledge" on page 409 of the textbook.

The Ring of Fire

So, did you discover the “ring of fire” that circles the Pacific Ocean? Did you decide whether or not you, as an Albertan, are likely to lose your home to a growing volcano? Or, perhaps you would like to buy a chunk of land on Loihi. You know that this new volcanic island will eventually be as nice as Hawaii.



Read pages 410 and 411 of the textbook to increase your knowledge of volcanoes.

4. Where is the largest volcano in the solar system located?



Compare your response with the one in the Appendix, page 106.

Finding Patterns

Volcanic eruptions cannot be prevented, but they can be predicted. Prediction is not an exact science. It utilizes many techniques. (You can measure the small earthquakes created by rising gases. You can use tilt meters to measure the swelling of the ground. You can watch variations in the output of gas and steam vents.) Volcanologists risk their lives on a daily basis to observe and measure volcanic activity. They are hoping to find patterns and signs that will make volcanic behaviour even more predictable.



Most earthquake and volcanic activity appears to be associated with tectonic plate boundaries. You saw this in the results of Investigation 5-J. In Lesson 2 you found that earthquakes are the result of the sudden release of energy along a fault or plate boundary. Volcanic eruptions occur when magma finds a fissure or vent in the crust and escapes to the surface. This is most easily done along plate boundaries. The patterns show there are three categories describing places of likely volcanic activity:

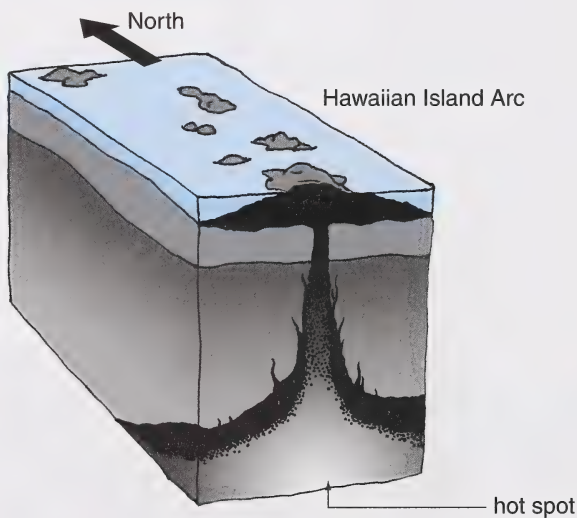
- (1) at mid-ocean ridges, where molten rock rises to the surface as the crust spreads

Iceland, located on the Mid-Atlantic ridge, is the result of volcanic activity.

- (2) at subduction zones, where the denser oceanic plates slide under the less dense continental plates

Rock subducted deep into Earth melts and the molten material rises towards the surface. Volcanic eruptions in this zone tend to be violent because the molten material must force its way through the crust.

- (3) at hot spots (like the one shown in the diagram) in a thin area in the middle of a plate



Here plumes of hot mantle material (magma) rise, melting the rock above and eventually erupting at the surface of the crust. The Hawaiian Islands are the result of volcanic activity over such a hot spot. It is interesting that the northernmost island in the arc is the oldest. The islands become progressively younger as you move south. Loihi, the newest island, is furthest south. The northern islands no longer have volcanic activity. This pattern provides further evidence that the tectonic plates are in motion. The oceanic plate carrying the Hawaiian Island Arc is sliding north over a hot spot. This results in the creation of new volcanic islands as it moves.

Going Further



People have witnessed volcanic eruptions for millennia. They've developed myths to explain the violence and destruction that accompany volcanic activity. Explore one or more of these myths. Try "Find Out Activity: Myths Retold" on page 410 of the textbook.

You have now completed the new concepts for this lesson. To go over what you studied, do the following questions.



5. Answer questions 1 to 4 of "Topic 6 Review" on page 411 of the textbook.



Compare your responses with those in the Appendix, page 106.

Looking Back



In this lesson you investigated the conditions in Earth's crust that lead to the formation of volcanoes. You also examined the patterns of volcanic eruptions. You found that some areas of the world are far more likely to experience volcanic activity than others.



Turn to pages 7 and 8 of Assignment Booklet 5A and answer questions 7 and 8.

Lesson 4: Mountains



What image comes to mind when you hear or read the word *mountain*? Is it a picture of rugged rock with a snowcap or icecap? Is it bare rock exposed to the sky with a few stunted trees? Or is it a forest-covered peak with gently sloping sides?

Depending on where in Canada you live, your image of a mountain may be any one of these. In Eastern Canada, mountains are usually covered with trees right to the top. In Alberta, most people envision the snow-covered peaks of the Rocky Mountains. But, even in Alberta, there are some mountains you might refer to as tree-covered hills. The point is, there are a variety of geologic features around Alberta and the world that can be called mountains. To explain this variety, you need to investigate the origin and age of mountains. You already know that processes like weathering and erosion are hard at work breaking down Earth's surface. This means that mountains cannot last forever. Bit by bit, piece by piece, the rock from which they are formed is moved. Wind, water, gravity, and ice take it to fill areas at lower elevations. But how do mountains form in the first place?

In Lesson 3 you studied the processes responsible for the creation of volcanic mountains. In this lesson you will study **diastrophic** mountains. Diastrophic mountains are formed as Earth's crust is deformed. The cause of this folding and faulting is due to movements of the tectonic plates.

Folding and Faulting

Turn to page 412 of the textbook and read the introductory paragraphs of “Topic 7: Mountains.”

Study the mountain in Figure 5.66 closely. It is an incredible natural formation, isn’t it? Can you imagine the amount of force required to fold these layers of sedimentary rock? Forces far beyond the capabilities of people, that’s for sure! This picture shows a piece of the Earth’s history. The history of plate movements are recorded in stone. This is yet another small piece of evidence supporting the theory of plate tectonics.



Now read “Mountain Formation and Distribution” on pages 412 to 414 of the textbook.

1. Define the following terms:

- *anticline*
- *syncline*
- *thrust fault*
- *fault block mountain*
- *complex mountain*



2. Can sediments be deposited in the pattern illustrated in Figure 5.66?
3. Under what conditions can rock fold without breaking?
4. What is another name for thrust fault?
5. Describe the tectonic differences between the Canadian Rockies and the American Rockies.
6. What is happening to the Juan de Fuca plate along the west coast of North America?



Compare your responses with those in the Appendix, page 107.

For layers of sedimentary rock to be transformed into mountains, several events and pre-existing conditions in Earth’s crust are required. In the next activity you will investigate how flat rock can build into mountains.



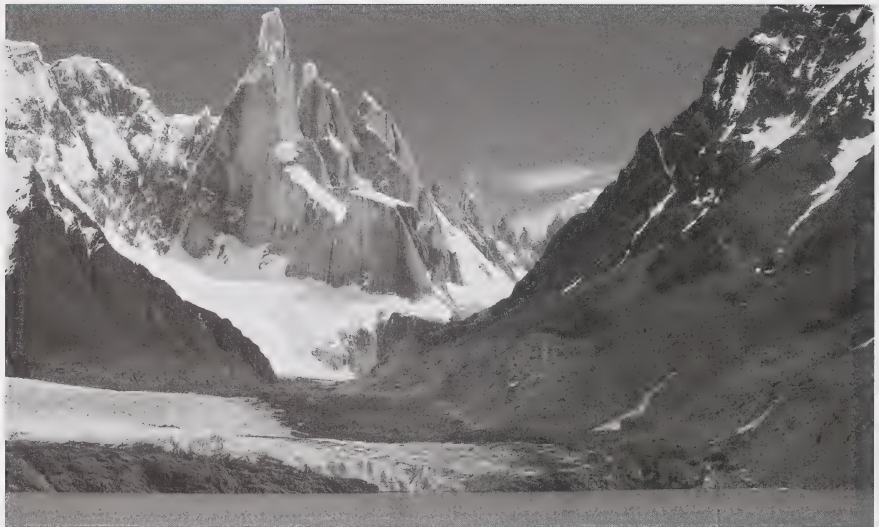
Find Out **Activity** Make a Mountain!

Read the entire activity on page 412 of the textbook. Then carry out the procedure, and carefully observe the results of your actions.

You can use different colours of modelling clay, sponges, towels, or even paper for this activity.



Aging Mountains



Have you ever seen the Canadian Rockies? They are a spectacular sight. People from all over the world marvel at them. Even people who have mountains in their own backyard are impressed. What makes the Rockies so special? How do they differ from mountains in eastern Canada, for example?



Read about age-related mountain features on page 414 of the textbook.

7. Explain how you differentiate between old and young mountains.



Compare your response with the one in the Appendix, page 107.

Does this drawing of a mountain look real? What facts or features did you use to judge it? If you thought it could exist, where would it exist? How would it have formed? Could you develop a theory explaining the presence and history of this mountain? The next activity guides you through the development of a mountain-building theory. You will locate mountain ranges on Earth. You will relate their locations to the patterns in earthquake and volcano locations.



Investigation 5-K Building a Mountain-Building Theory

Read the entire investigation on page 415 of the textbook.

8. a. Carry out the steps of the procedure. Use the map at the back of the Appendix. Feel free to colour your map.
- b. Answer questions 1, 2, and 3 of “Analyze.”
- c. Answer questions 4 and 5 of “Conclude and Apply.”
- d. Answer questions 6 and 7 of “Extend Your Knowledge.”

Check your responses with your teacher or home instructor.

end of investigation

You have now completed the new concepts for this lesson. To test your knowledge of the concepts of this lesson, answer the following questions.



9. Answer questions 1 to 7 of “Topic 7 Review” on page 416 of the textbook.

Compare your responses with those in the Appendix, pages 107 and 108.

Looking Back

In this lesson you related tectonic activities in Earth's crust to mountain building. You saw that the location of mountains is related to tectonic plate locations. You also saw that tectonics determine the type of mountain.

Section 2 Review



To review the concepts covered in this section, turn to page 417 of the textbook and answer the following “Wrap-up: Topics 4–7” questions.



1. Answer question 1 of “Reviewing Key Terms.”
2. Answer questions 2 to 6 of “Understanding Key Concepts.”



Check your responses with your teacher or home instructor.

Conclusion

In this section you investigated Earth's crust, its composition, and its features. You also studied the theory of plate tectonics, which was developed to explain some of these features.

Your skin and Earth's skin are both quite special. You've seen that they're relatively thin. They both slide around over whatever's underneath, and they both are continuously changing. Since studying this section, you can probably think of many other ways that they are alike.



Turn to pages 8 and 10 of Assignment Booklet 5A and answer questions 9 to 13.



Section 3

Fossil Formation and Earth's History

Are you beginning to understand the basic idea of this module? The processes of today are the processes of the past and the future. Because of this, people are able to read the history of Earth in the rocks! What does the mammoth skeleton in the picture tell you? Fossils like this provide valuable information about the organisms and events of the past.

The preceding sections introduced the processes and mechanisms that shaped Earth's crust. What is needed now is a time scale. How do geologists establish the age of rocks and geologic events? The record is there in Earth's crust. What data do they collect and interpret to establish geologic time?

In this section you will investigate fossils. How are fossils formed? What do fossils tell you about Earth's past? How do fossils help in the development of a geologic time line for Earth's history? You will also study how fossil fuel deposits accumulate and the technologies used to locate them.



Lesson 1: Fossils



If you live in Alberta, you are probably familiar with the existence of fossils. The dinosaur remains found in Alberta are world-renowned. You may even have a piece of petrified wood (like the petrified logs shown in the photograph). How are the remains of plants and animals fossilized? Why is Alberta so fossil-rich?

In this lesson you will explore the conditions necessary for fossilization. You will learn how different types of fossils are formed. In addition, you will interpret fossil clues.

Fossil Types

From previous modules you know that most dead organisms are either eaten or they decompose. Traces of their presence are generally wiped away by wind or water. How can the remains of dead plants and animals be saved from decay and destruction? They need to be protected from scavengers and oxygen. For fossilization to be successful, circumstances must be just right. Traces and remains must be covered quickly and with minimal disturbance. Remains can be preserved by being rapidly covered, dried, frozen, or immersed in tar. The quality of fossils depends on the conditions existing at the time of the death.

DID YOU KNOW?

?

Trilobites are among the first animals with a hard skeleton. This is one of the reasons for the abundance of trilobite fossils. The name refers to the three lobes in their exoskeleton, which they shed, similar to modern insects, crabs, and lobsters.



Read the introductory paragraphs of “Topic 8: Fossils” on page 418 of the textbook. Continue by reading “Types of Fossils” and “Fossil Mould and Cast Formation” on pages 418 to 420. You will find a description of the of fossil types and how fossils are formed.

1. The Burgess Shale site in British Columbia is a tremendous source of fossils. What is so remarkable about the fossil samples found at this site?
2. Classify each of the following fossils pictured on pages 418 and 419 of the textbook. Use the terms *petrified*, *original remains*, *carbonaceous film*, *trace fossil*, *cast*, or *mould*. The first one has been done for you.

Fossil	Fossil Type
Figure 5.74	cast
Figure 5.76	
Figure 5.77	
Figure 5.78	
Figure 5.79	
Figure 5.80	
Figure 5.81	



Compare your responses with those in the Appendix, page 108.

Going Further



Play Mother Nature! Create your own fossils! Do “Find Out Activity: Mystery Fossils” on page 420 of the textbook.



Drought or flood? Does either condition seem favourable to fossil formation? Perhaps both are, if the conditions are appropriate. In the next activity you will investigate materials and conditions for their potential to produce a fossil mould and cast. Your conclusions and experiences can help you understand the natural conditions required for fossil formation.

Investigation 5-L Make a Lasting Impression



Read the entire investigation on page 421 of the textbook.

Carefully follow the steps of the procedure.

3. Answer the following on page 421 of the textbook.

- a. questions 1, 2, and 3 of “Analyze”
- b. question 4 of “Conclude and Apply”



Check your responses with your teacher or home instructor.

end of investigation

Points of Interest



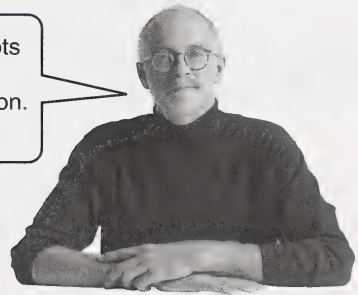
Read the information on page 422 of the textbook. You will gain an insight into fossil interpreters of the past and present.

4. Dr. Phil Currie is a paleontologist. List the scientific fields paleontologists need to be familiar with.



Compare your response with the one in the Appendix, page 108.

You have now completed the new concepts for this lesson. It's time to test your understanding of the concepts in this lesson. Answer the following questions.



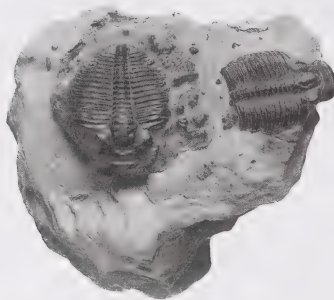
5. Answer questions 1 to 4 of “Topic 8 Review” on page 422 of the textbook.



Compare your responses with those in the Appendix, pages 108 and 109.

Looking Back

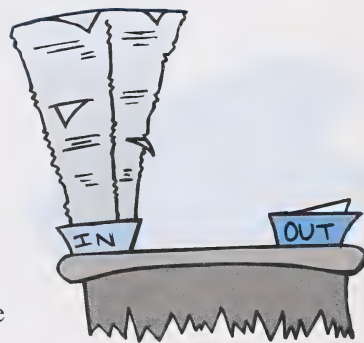
Isn't it amazing to look at the remains of an organism that has not existed for thousands or millions of years? In this lesson you studied the process of fossilization. You were also shown the different types of fossils found. In the next lesson you will examine the role fossils play in interpreting Earth's history.



Turn to pages 1 and 2 of Assignment Booklet 5B and answer questions 1, 2, and 3.

Lesson 2: Geologic Time

Which got deposited in the box first—the paper on the top or the paper on the bottom? You use common sense to answer this question. The most recent papers are found on top of the pile and the oldest on the bottom of the pile. The position in an undisturbed stack can be used to find the age of the items. How would you decide on the relative age of the items if someone had shuffled the papers? The obvious answer would be to look for a date on the document or to look at the content of the document. Geologists and paleontologists can use a similar approach to determine the age of rocks and fossils.



In this lesson you will examine methods and technologies used by geologists and paleontologists. You will see how they determine the age of fossils and rocks and define geologic time.

Relative Dating (Qualitative)

Which got deposited first—the sediments at the bottom of the profile (pile) or the sediments at the top? Scientists often use common sense to draw inferences about the environment. (It's often backed by observation, experimentation, and additional information.) From your own experience, you know that a layer must be in place before another layer can be piled on top of it. You cannot build a pile of blocks from the top down.



Geologists refer to this common sense idea as the **principle of superposition**. Turn to page 423 of the textbook and read the introductory paragraphs of “Topic 9: Geologic Time.”

1. Define the following terms:

- *principle of superposition*
- *strata*
- *relative dating*
- *index fossil*

2. Study Figure 5.82 on page 423 of the textbook. Suggest why the principle of superposition can be applied to this rock formation.



Compare your responses with those in the Appendix, page 109.

You wear a clean pair of socks each day. Each night, you pile your dirty clothes into the laundry hamper in your room. One day, you're asked, “When did you last do your laundry?” You answer, “I don't know!” But you know how to find out. You can use “stratification” and “index fossils” to find out. After all, those socks have been there so long they should be well-preserved by now!



The next activity challenges you to apply some of the relative dating techniques used by geologists.



Find Out **Activity** Which Rock Is the Oldest?

Refer to the activity on page 423 of the textbook. Carefully read and carry out the steps of the procedure.

3. Answer questions 1 and 2 of “What Did You Find Out?”



Compare your responses with those in the Appendix, page 109.

Absolute Dating (Quantitative)

Radioactivity is a word that makes some people view nasty, dangerous images. Did you know that low-level radiation is around and within you? Radioactive elements have been incorporated into your bone and tissues. They’re even in the food you eat and the air you breathe. Scientists will be able to date your remains for up to 50 000 years. That is, if you are lucky enough to become fossilized!

It is often useful for geologists to determine an absolute age for rocks and fossils. Such an absolute age does not rely on comparing with another strata or other fossils. Much like documents have a date stamp, so do rocks and organic remains. Radioactive minerals provide geological date stamps.



Turn to page 424 of the textbook and read “Clues from Technology.” You will be given some details of the absolute dating technologies.

4. Define the following terms:

- *half-life*
- *radiometric dating*
- *radiocarbon dating*

5. Why is radiocarbon dating only applicable to fossils up to 50 000 years of age?
6. Do “Math Connect” on page 424 of the textbook.



Compare your responses with those in the Appendix, pages 109 and 110.

Fossils and rocks tell tales if you understand their language. The next activity illustrates how fossils present in rocks can help you determine their geologic age.



Find Out **Activity** Tell-Tale Layers

Refer to the activity on page 425 of the textbook. Carefully read the steps of the procedure.

7. Answer the questions posed in steps 3 and 4 of the procedure.



Compare your responses with those in the Appendix, page 110.

The Geological Time Scale



As rivers carve through Earth's crust, they reveal bits of Earth's geological history. The Colorado River has cut through eons worth of rock. It has exposed tales of organic and inorganic changes that go back almost two billion years. The fossil record exposed in the canyon walls begins with primitive algae. It continues through to dinosaurs and to the remains of early camels, horses, and humans. The historic information provided by these exposed strata is very valuable.



Turn to pages 425 and 426 of the textbook and read “Geologic Time Scale.” You will examine the development and organization of a geologic time scale of Earth’s history.

8. Create a graphic organizer that shows the meanings of and relationships between the terms *eon*, *era*, and *period*.
9. Give a reason why there is little fossil evidence of life in the Precambrian.
10. During which period were the great coal deposits laid down? Can you suggest why that period was given this name?



Compare your responses with those in the Appendix, page 110.



Like temperature, age can be relative. Consider the two organisms above. Is the human or the dinosaur older? You could actually choose either one and still be right, depending on the time scale you used. Geologically, the dinosaur is older. Dinosaurs have been extinct for 65 million years. (Although, on the geologic time scale, that is actually a short period of time.) On the human time scale, the elderly man has the baby dinosaur beat by a long shot.

The next activity will help you familiarize yourself with the geologic time scale. You will develop a geologic time line based on the topics you have studied in this module.

Find Out **Activity** Call That Old?



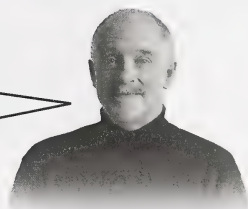
Refer to the activity on page 427 of the textbook. Read the procedure carefully. Then carry out the steps of Procedure.

11. Answer the following on page 427 of the textbook.
 - a. questions 1 and 3 of “What Did You Find Out?”
 - b. question 4 of “Extension”



Compare your responses with those in the Appendix, page 111.

You have now completed the new concepts for this lesson. Now it's time to test your understanding of what you covered.



12. Answer questions 1 to 4 of “Topic 9 Review” on page 427 of the textbook.



Compare your responses with those in the Appendix, page 111.

Looking Back

You have climbed to the top of the pile. You have verified your common sense and practical knowledge of geological processes. It matches quite well with scientific information gathered and developed over centuries. Scientific knowledge and awareness can take your day-to-day experience a step further. It deepens your understanding of the natural processes taking place around you.

In this lesson you studied a few techniques used to age rocks and fossils. You then related this information to the geologic time scale. You summarized this with your own time line of Earth's history.



Turn to pages 2 to 5 of Assignment Booklet 5B and answer questions 4, 5, and 6.

Lesson 3: Fossil Fuels



Oilfield pumps and draglines for coal and oil sands are common sights in Alberta. Most of Alberta is covered with sedimentary rocks deposited in ancient seas and swamps. What happened to the remains of the organisms that lived, died, and were buried during those times? They have changed into the fossil fuels people use today.

In this lesson you will study fossil fuels. Where did they come from? Where are they found? How are they found? What technologies are used to find them?

Locating Fossil Fuels

How would you go about locating something buried deep below the ground? You could dig and you might get lucky; but your chances are quite small! Finding fossil fuels requires much more sophisticated technology and information.

Scientists consider fossil fuels to be the result of animal and plant remains. They were deposited along with silt and mud sediments in ancient swamps and ocean basins. The solid fuels, like coal, are found in discrete layers among other varieties of sedimentary rocks. The liquid fuels have the capacity to flow through porous rock, like sandstone and limestone. These fossil fuels require an impermeable layer of rock, like shale, to trap them.





Read the introduction to “Topic 10: Fossil Fuels” on page 428 of the textbook. Then read “Finding and Mining Fossil Fuels” on pages 428 and 429 for a quick look into how fossil fuels are found.

1. What are the conditions under which animal and plant remains in sedimentary basins are transformed into fossil fuels?
2. In sedimentary deposits, what is the usual source of coal? of natural gas? of oil?
3. Describe another theory that has been proposed for the origin of fossil fuels.
4. Compare and contrast the use of seismic waves in the exploration for fossil fuels and in monitoring earthquakes.



Compare your responses with those in the Appendix, page 111.

The next investigation challenges you to make decisions. To locate an oil deposit, where should an exploratory well be drilled?

Investigation 5-M Where Shall We Drill?



Refer to the investigation on page 430 of the textbook. Read the introductory information.



Get the block diagram that is provided at the back of the Appendix. This is the same diagram as shown on page 431 of the textbook. Then carefully follow the steps of the procedure.

5. Answer the following on page 430 of the textbook.

- a. questions 1 to 4 of “Analyze”
- b. questions 5 and 6 of “Conclude and Apply”

Note: The page reference in question 6 should be page 429, not 431.



Compare your responses with those in the Appendix, page 112.

end of investigation

You have now completed the new concepts for this lesson. Now it's time to test your understanding.



6. Answer questions 1 to 4 “Topic 10 Review” on page 432 of the textbook.



Compare your responses with those in the Appendix, page 112.

Looking Back

Can you imagine living and working on an oil rig? Deep-sea drilling rigs are not found in Alberta and for good reason! These extremely high-tech rigs are becoming more and more common on the world's oceans. Perhaps, one day, you will find yourself working on one.

In this lesson you investigated the formation of fossil fuels, the geologic conditions favourable for their accumulation, and the technologies used to locate them.



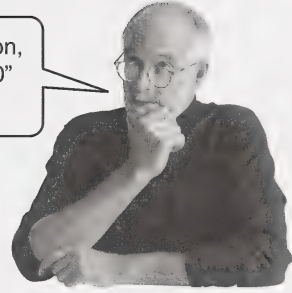
Turn to page 5 of Assignment Booklet 5B and answer questions 7, 8, and 9.



Section 3 Review



To review the concepts covered in this section, answer the following “Wrap-up: Topics 8–10” questions on page 433 of the textbook.

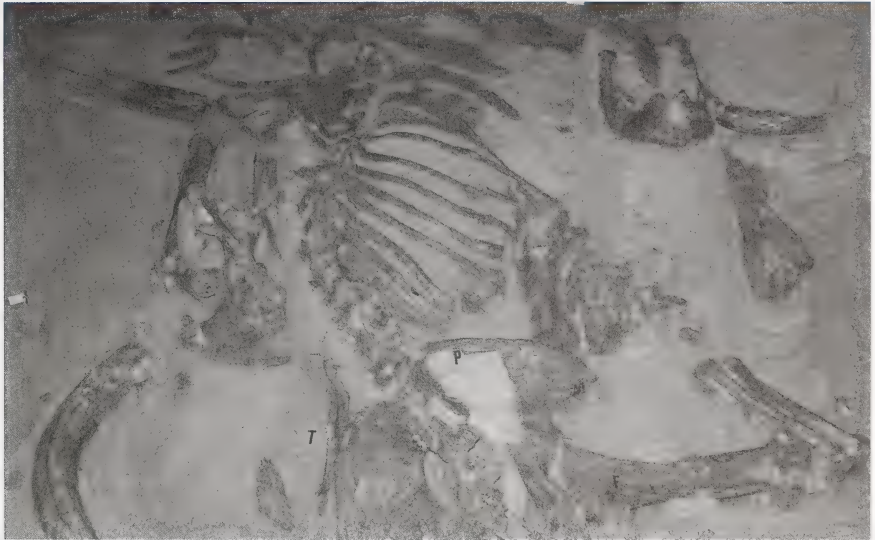


1. Answer question 1 of “Reviewing Key Terms”
2. Answer questions 3, 4, and 5 of “Understanding Key Concepts.”



Check your responses with your teacher or home instructor.

Conclusion



Now you know how fossils help geologists tell time. The mammoth skeleton shown is from the recent past (in geologic terms). Other fossils tell about times much farther in the past. Careful study has let scientists build a geologic time line. It stretches back over billions of years.

In this section you examined some topics in Earth science. You looked at how and under what conditions fossils are formed. You saw how scientists interpret the geologic and fossil records found in Earth’s crust. You then studied how this knowledge contributes to the exploration for fossil fuel deposits and their recovery.

Module Summary

Do you view this landscape from a different perspective now? Can you suggest its geologic history? Can you now identify the forces and processes that shaped it into its present form? What evidence of ongoing incremental change is there? Barring catastrophic events, how will this scene change over the next hundred or million years?



In this module you explored the geologic past and the composition of Earth's crust. You studied the characteristics of rocks and minerals and the processes responsible for their formation and evolution. You then investigated the methods and technologies used by scientists interested in Earth's crust. You saw how they monitor tectonic activity, explore for minerals, and determine the crust's composition. You also learned how they gather and interpret evidence of the crust's history.



To review the concepts covered in this section, turn to page 438 of the textbook and review the concepts listed under “Unit at a Glance.” Then answer the following “Unit 5 Review” questions on pages 438 to 441.

1. Answer questions 1 and 2 of “Understanding Key Concepts.”
2. Answer questions 6, 8, 9, and 10 of “Developing Skills.”
3. Answer questions 12, 14, and 17 of “Problem Solving/Applying.”
4. Answer questions 21, 22, 24, 27, and 30 of “Critical Thinking.”



Compare your responses with those in the Appendix, pages 113 and 114.



**Turn to pages 6 to 9 of Assignment Booklet 5B
and complete the Final Module Assignment.**

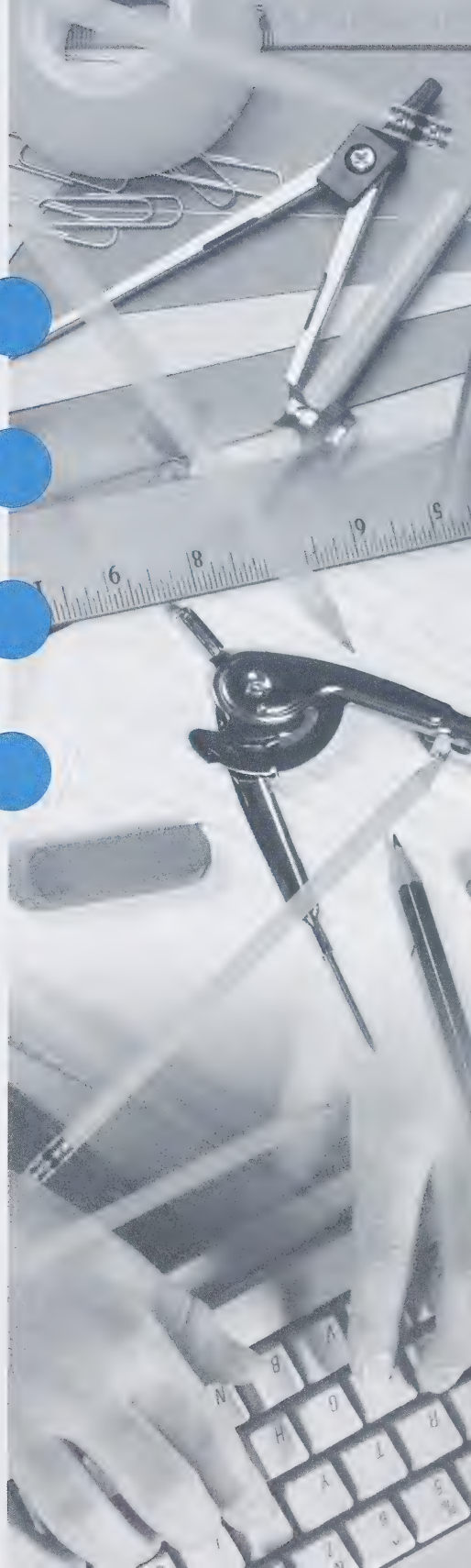
Appendix

Glossary-----●

Suggested Answers-----●

Image Credits-----●

Cut-out Learning Aids-----●



Glossary

abrasion: the wearing down of rock by wind and moving ice and water

chemical weathering: a weathering process by which rocks and minerals change into a new substance

continental drift: the theory that today's continents were joined into larger landmasses and have since split and drifted on the surface of Earth

element: a pure substance composed of only one type of particle

It cannot be broken down into simpler substances by chemical means.

energy: the ability of a substance or system to do work

Energy exists in several forms: chemical, kinetic, radiant, thermal, and so on.

eon: a unit of time equal to one billion years

epicentre: a point at the surface of Earth that is directly above the seismic focus of an earthquake and where the earthquake vibrations reach first

erosion: the mechanical and chemical wearing away of rock and soil of Earth's crust

erratic: a stone or boulder carried by ice to a place where it rests on or near bedrock of different composition

fault: a fracture in rock along which the adjacent rock surfaces are displaced in any plane

force: a push or pull

geology: the science of Earth, its history, and its life as recorded in rocks and minerals

Geology includes the study of geologic features of an area, such as the geometry of rock formations, weathering and erosion, and sedimentation

hydrocarbon: a substance composed only of carbon and hydrogen

igneous rock: rock formed when magma or lava cools and solidifies

kinetic energy: the energy an object or system has due to its motion

lava: magma that reaches the surface of Earth's crust

leaching: the separation of or dissolving out of the soluble parts of rock or soil

mantle: the middle layer of Earth that lies between the crust and the core

mass: the quantity of matter in an object

magma: the molten rock material from which igneous rocks are formed

mechanical weathering: the process of weathering by which physical forces break down or reduce rock to smaller and smaller fragments, involving no chemical change

mineral: an inorganic, naturally occurring, solid material

Minerals can be elements or compounds (consisting of two or more elements).

paleogeology: the geology of the past

paleontology: the study of life of the past as recorded by fossil remains

petroleum: a naturally occurring, complex hydrocarbon that can be gaseous (natural gas), liquid (crude oil), solid (tar, bitumen), or a combination of states

potential energy: the energy an object or system has due to its position or condition; stored energy

Potential energy includes gravitational potential energy, chemical potential energy, and so on.

pressure: force per unit area

principle of superposition: a geological theory stating that the oldest layer in undisturbed layers of rock is found on the bottom and the youngest layer on the top

rock: a natural material composed of one or more minerals

rock cycle: the interrelated sequence of geologic events by which rocks are initially formed, altered, destroyed, and reformed over long periods of time

seismic focus: the point of origin of an earthquake

seismic waves: waves generated by seismic activity, movement in Earth's crust

seismogram: the record made by a seismograph

seismograph: an instrument that records vibrations in Earth's crust, especially earthquakes

seismology: the science of earthquakes

vent: an opening in Earth's crust through which magma can escape, forming lava

wave: a disturbance or vibration passing from one point to another in a medium

weight: the force of gravity exerted on a mass

Suggested Answers

The answers in this Appendix are an important part of this Science course. Read them carefully when checking your work. They provide additional information, examples, and clarification. They also give you a quick way to see if your answer is right. It is a good idea to copy the things you learn into your notebook. What you learn from the suggested answers is often used later in the module or course. Refer to them as needed.

Section 1: Lesson 1

1. *Rock* is a natural material composed of one or more minerals.

A *mineral* is an inorganic, naturally occurring, solid material. Minerals can be elements or compounds (consisting of two or more elements).

The *crust* is the thin, outermost layer of Earth.

An *element* is a pure substance composed of only one type of particle. It cannot be broken down into simpler substances by chemical means.

A *compound* is a pure substance made up of two or more elements. A compound has its own distinct properties.

A *pure substance* is a substance that consists of only one kind of particle.

2. These items are easy to take into the field. They allow the geologist to obtain a reasonable estimate of the hardness of each mineral. This will help identify the minerals and rocks she finds.
3. Feldspar will scratch apatite because feldspar is harder than apatite.
4. *Crystal* is the naturally occurring building block of minerals. Crystals have straight edges, flat sides, and regular angles.
5. There are only a few crystal systems and over 3000 minerals. Particles of a particular mineral are always organized in one particular system. The mineral shares the system with many other minerals. Crystals and crystal systems are just one clue to mineral identification.
6.
 - a. Answers will vary. Your description may include colour, size, number of limbs, length of tail, type of teeth, size and shape of ears, and length of fur or hair.
 - b. No, Lionel would need a lot of clues to recognize a fox, chipmunk, or bear when he saw one. For example, there are a lot of organisms that have four limbs.
7. Answers will vary. Properties describing minerals may include colour, texture, whether or not you can see through them, how heavy or dense they are, whether they are shiny or dull, how they break apart, and so on.

8. *Impurities* are substances other than the main constituent in a mineral sample.

Lustre is the shiny appearance of a mineral surface.

Streak is the colour of the powdered form of a mineral.

Cleavage is the property of a crystal that allows it to break along smooth, flat surfaces or planes.

Fracture is the property that causes a crystal to break with jagged edges.

9. Check your responses with your teacher or home instructor.

10. Check your responses with your teacher or home instructor.

Section 1: Lesson 2

1. *Igneous rock* is rock formed when magma or lava cools and solidifies.

Magma is the molten rock material found below Earth's surface from which igneous rocks are formed.

Intrusive rock is rock formed when magma cools below Earth's surface.

Lava is magma that reaches the surface of Earth's crust.

Extrusive rock is rock formed when lava cools above ground.

2. a. The dog, cat, and adult human are all bigger because they have had more time to grow.
b. Answers will vary. A sample answer is given.

As the length of the growth period increases, size will increase. It could be limited by some factor or combination of factors, such as space, materials, or genetics.

3. Check your responses with your teacher or home instructor.

4. *Sedimentary rock* is rock formed by compacting sediments. It's the most common type on Earth. There are three classes of sedimentary rocks: clastic, chemical, and organic. Clastic sedimentary rocks are composed of inorganic rock fragments. Chemical sedimentary rocks are formed by the precipitation or evaporation of minerals from ancient seawater. Organic sedimentary rocks are composed of dead animal or plant matter.

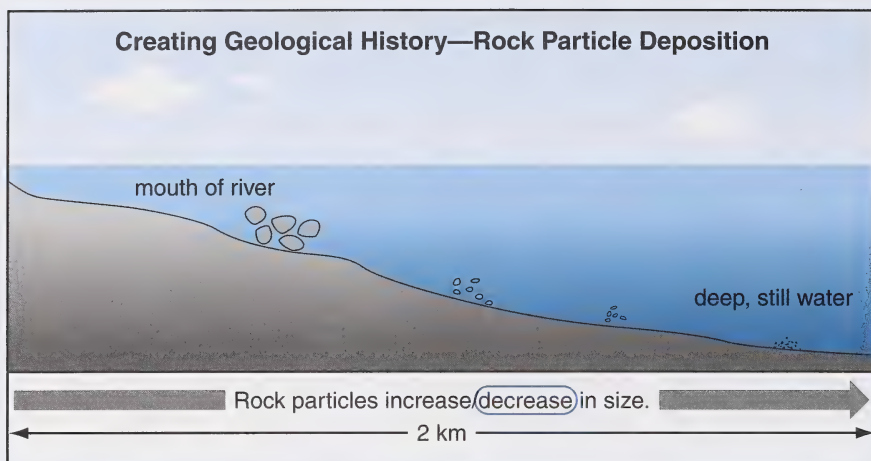
Sediment is loose, inorganic or organic materials (e.g., minerals) and animal or plant remains.

Stratification is the arrangement of sediments in visible layers.

Compaction is the process of compressing layers of sediment by the weight of water and other sediments deposited on top.

Cementation is the process of sticking pieces of sediments together by a cement formed when water dissolves some of the sediments.

5.



6.
 - a. The crystals had a longer period of uninterrupted growth.
 - b. Some type of impurity, like hematite, produces the red colour.
 - c. The crystal system is cubic.
7. *Metamorphic rock* is changed rock. Due to intense heat and pressure, the minerals in a rock are altered without melting.

Parent rock is the original rock from which a metamorphic rock is formed. For example, shale is the parent rock of slate.
8. Answers may vary. Some examples are given.

Parent Rock	Metamorphic Rock
limestone	marble
granite	gneiss
sandstone	quartzite
shale	slate
slate	schist

9. Check your response with your teacher or home instructor.
10. and 11. Check your responses with your teacher or home instructor.
12. The *rock cycle* is the naturally occurring, continuous process by which rocks change form over a long period of time.
13. The rock cycle links the rock families with eight different processes: weathering, erosion, compaction, cementation, heating, melting, cooling, and crystallizing.
14. *Compost* is decaying plant matter.

Fertile means nutrient-rich. Fertile soil can supply the necessary nutrients for plant growth.

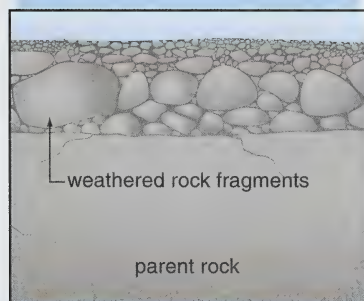
Humus is the dark, nutrient-rich part of soil that comes from the partial decomposition of plant or animal matter.

Leaching is the removal of the soluble parts of rock or soil by water flowing over or through them.

A *soil profile* illustrates how the layers of soil are divided. It provides details of the content and composition of each layer of soil of a particular soil sample.

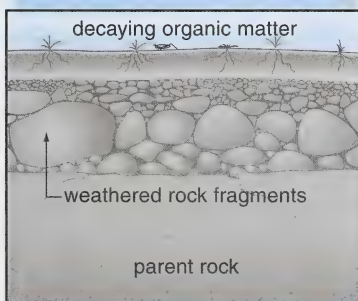
Topsoil is the top layer of soil. It is the most mature layer in a particular profile.

15. Diagrams will vary. Sample diagrams are given.



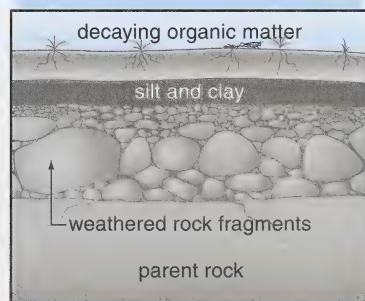
Weathered Rock

This layer has lots of cracks and spaces for air and water.



Immature Soil

A layer of decaying organic matter builds up. This comes from the small plants and animals that lived there.



Mature Soil

A layer of mineral-rich silt and clay forms between the rock fragments and the organic matter. The clay holds the minerals that water leaches out of higher layers.

16. Check your responses with your teacher or home instructor.

Section 1: Lesson 3

1. *Weathering* is the wearing down or breaking down of rock due to environmental conditions.

Mechanical weathering is the process of weathering by which physical forces break down or reduce rock to smaller fragments. It involves no chemical change. An example of mechanical weathering is rock rolling down a hill, hitting another rock, and breaking into smaller pieces.

Frost (ice) wedging is the freeze-thaw cycle that breaks apart rock. Water enters a tiny crack (fissure) in the rock. The water then freezes and thaws repeatedly over a period of time. When water freezes, it expands. This makes the fissure larger, allowing more water to enter during the next thaw phase. When the water freezes again, the cycle repeats. Eventually, the rock breaks into smaller parts.

Chemical weathering is the process of weathering by which rocks and minerals change into a new substance. Acid rain is an example of an agent causing chemical weathering.

Biological weathering is the chemical or mechanical weathering of rock caused by living organisms. A root of a tree breaking up rock as it grows is an example of biological weathering.

2. Burning coal to generate electricity releases nitrogen and sulfur oxides into the air. These chemicals combine with water in the air to produce sulfuric and nitric acid. Acid precipitation reacts with marble, limestone, and dolomite, which are used to create structures and statues. Chemical weathering breaks down these structures.
3. The fungus uses biological and chemical weathering to obtain minerals from the rock.
4. a. **Textbook questions 1 and 2 of “Analyze,” p. 375**
 1. The manipulated variable was the type of rock.
 2. The responding variable was whether the rock fizzed or not (reacted with the acid to produce a gas or bubbles).b. **Textbook questions 3, 4, and 5 of “Conclude and Apply,” p. 375**
 3. Rocks that fizz would be subject to chemical weathering more than those that did not fizz.
 4. Rocks that didn’t react with acid would be least affected by chemical weathering.
 5. Answers will vary depending on your samples.c. **Textbook question 6 of “Extend Your Skills,” p. 375**
 6. *Chemical weathering* is a weathering process by which rocks and minerals change into a new substance.
5. *Erosion* is the process of moving rock and soil from one place to another.

Abrasion is the wearing down of rock by particles moved by wind, ice, or water.

6. Wind, moving water, glaciers, and gravity are the agents of erosion. They transport rock materials from the location at which they were weathered. Notice that there are no chemical or organic agents. However, with modern technology, humans could certainly be considered agents of erosion.
7. This is a geologically young riverbed because of its steep banks.
8. **Textbook questions 2, 3, and 4 of “Topic 3 Review,” p. 380**
2. Mechanical weathering is the process of weathering by which physical forces break down or reduce rock to smaller fragments. Mechanical weathering involves no chemical change.
3. Chemical weathering results from rocks reacting with substances dissolved in water or the air, such as acids. Biological weathering involves both chemical and physical weathering. Living organisms contribute to the breakdown of rock by secreting acidic solutions onto the rock. They also cause physical breakdown when roots, for example, grow into fissures and increase in size, splitting rock apart.

4.

Erosion Cause	Description of Process
glaciers	Glaciers erode the surface and carry sediment far from its origin, depositing it along the sides. Large rocks frozen into the ice scrape the surface, causing striations on the surface.
gravity	Gravity causes rock to move from a higher elevation to a lower one. Landslides, rockslides, and mudslides are the mechanism. Gravity also plays a role when glaciers and water move rock material from a higher elevation to a lower one.
living organisms	Living organisms break down rock by both chemical and physical means. Substances deposited on the rock by either plants or animals react with the rock, causing chemical weathering. Roots growing in fissures cause mechanical weathering. Humans and animals also disturb the surface and move things around (e.g., gopher holes, explosives, canals, graders).
water	Water contributes to both chemical and mechanical weathering. Water dissolves substances, forming acids that react with rock and wearing it down. It also erodes the surface by its motion. The sediments moving water carries cause abrasion. Rain water, rivers, and ocean waves are examples of moving water causing erosion.
wind	Wind, like moving water, erodes the surface by moving particles from one place to another. The particles carried by wind cause erosion by abrasion.

Section 1 Review

1. and 2. Check your responses with your teacher or home instructor.

Section 2: Lesson 1

1. The *mantle* is the middle layer of Earth. It lies between the crust and the core and consists of rock material.

The *outer core* is the zone of Earth's interior that lies between the mantle and the inner core. It consists of molten iron and nickel.

The *inner core* is the innermost zone of Earth. It consists of solid metal.

2. Your diagram should be similar to Figure 5.35 on page 382 of the textbook.
3. Mesosaurus and lystrosaurus fossils have been found in both Africa and South America. Also, fossils of glossopteris (a plant) have been found in Africa, Antarctica, India, South America, and Australia.
4. Some suggestions were as follows:
 - A land bridge existed between Africa and South America.
 - Animals crossed the water barrier on fallen trees.
 - Water levels were lower and animals were able to cross on island bridges.



5. a. **Textbook questions 1 and 2 of “Analyze,” p. 386**
 1. You most likely found that the shorelines did not match exactly. That’s because it’s the continental shelves that match.
 2. North America and Europe are a difficult match. Oceans and seas were not the same. One means of testing is to try a fit along the continental shelf instead of the current shoreline.
- b. **Textbook question 3 of “Conclude and Apply,” p. 386**
 3. The geological, biological, and meteorological evidence supported Wegener’s idea.

6. *Sonar* is a technology that bounces sound waves off an object to determine the object's distance from the source.

The *theory of seafloor spreading* is a theory explaining why rock next to a mid-ocean ridge is younger than the rock further away. As the ocean floor spreads, magma wells up and solidifies, forming new rock.

7. The Atlantic Ocean floor is spreading about 2 cm per year.

8. Check your responses with your teacher or home instructor.

9. **Textbook questions 1, 2, and 3 of “What Did You Find Out?,” p. 389**

1. The paper represents the magma rising and forming new crust.
2. The crack between the desks represents a fissure in the crust where magma reaches the surface, such as a rift valley or mid-ocean ridge.
3. The pattern drawn first (at the beginning of the activity) represents the oldest rock. The last pattern drawn represents the youngest rock.

10. A *plate* is one of several pieces that divides Earth's crust.

Converging plates are two plates moving toward one another.

Diverging plates are two plates moving away from one another.

The *theory of plate tectonics* is a theory stating that the crustal plates are always moving on the mantle.

11. J. Tuzo Wilson suggested that some plates slide past one another instead of pushing together or pulling apart.
12. A *subduction zone* is a plate boundary where one plate slides under the other plate.
13.
 - a. When continental plates converge, their leading edges crumble, forming mountains (e.g., Himalayas).
 - b. When a heavier oceanic plate and a lighter continental plate converge, the oceanic plate subducts under the continental plate.
 - c. When oceanic plates converge, one plate slides under the other, forming volcanoes and island arcs.
 - d. When oceanic plates diverge, a ridge develops where magma from the mantle reaches the surface and cools, forming new crustal rock.
 - e. When continental plates diverge, a rift valley develops.
14. Check your responses with your teacher or home instructor.

Section 2: Lesson 2


1. A *seismograph* is an instrument that records vibrations in Earth's crust, especially earthquakes.

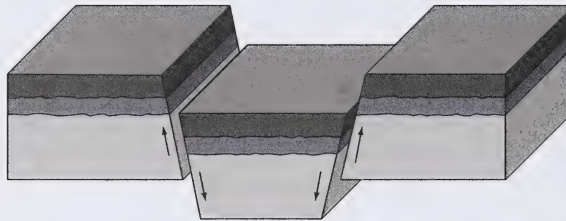
Bedrock is solid rock under soil and layers of looser rocks.


The *Richter scale* is an arbitrary scale used to denote the magnitude (strength) of an earthquake.

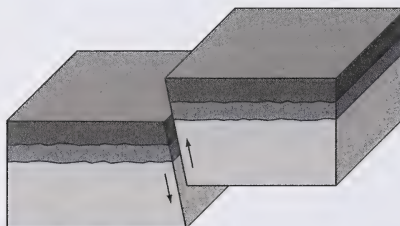
A *seismic wave* is a wave generated by seismic activity (movement in Earth's crust).

An *aftershock* is a smaller earthquake that follows a larger one. It originates at or near the focus of the larger earthquake.

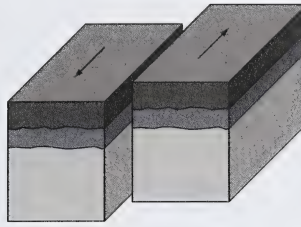
2. A seismograph must be attached to the bedrock so the vibrations of an earthquake can be felt.
3. A *focus* is the point of origin of an earthquake.
4. The height of the seismogram is an indication of the magnitude (strength) of an earthquake.
5. An *epicentre* is a point at the surface of Earth that is directly above the seismic focus of an earthquake. It is the point earthquake vibrations reach first. Surface waves (or L waves) travel out from this point.
6. Check your responses with your teacher or home instructor.
7. Check your responses with your teacher or home instructor.
8. Check your responses with your teacher or home instructor.
9. A *normal fault* is a fault in which one block of rock moves downward relative to the other. This leaves a cliff shaped like .



A *reverse (thrust) fault* is a fault in which one block of rock moves upward relative to the other. This leaves a cliff shaped like .



A *strike-slip or transform fault* is a fault along which movement is horizontal.



10. a. This is a normal fault caused by tension.
 - b. This is a strike-slip or transform fault caused by shearing.
 - c. This is a reverse or thrust fault caused by compression.
11. Normal faulting is likely to occur in areas of seafloor spreading.

Reverse faulting is likely to occur at converging plate boundaries (mountain-building regions), where compressive forces are active.

Strike-slip faulting is likely to occur near sliding plate boundaries.

12. Check your responses with your teacher or home instructor.
13. Check your responses with your teacher or home instructor.

14. **Textbook questions 2 to 5 of “Topic 5 Review,” p. 405**

2. Circles are used to represent the distance a seismograph is from the epicentre of an earthquake. If only two circles are used, two intersection points occur. If at least three circles are used, the circles will intersect at only one point.
3. In Canada, earthquakes usually occur along the coast of British Columbia, in the Yukon Territory, north of Hudson Bay, along the eastern coast, and in the St. Lawrence River valley.
4. a. Along a normal fault, the rock above the fault moves down.
- b. Along a reverse fault, the rock above the fault moves up.
- c. Along a slip-strike fault, the rock movement is horizontal.
5. In a high-rise community, stay inside to avoid falling debris and hide under a desk, table, or similar object. In a residential community (one- or two-floor buildings), you would be safer outside.

Section 2: Lesson 3

1. A *vent* is an opening in Earth's crust through which magma can escape, forming lava.

Dormant means temporarily inactive. An inactive volcano is said to be dormant.

2. Because the oceanic plate slides gradually under the continental plate, the subduction zone reaches many kilometres inland. Throughout the subduction zone, magma can reach the surface through fissures in the crust. This forms a volcano at the surface.

3. a. **Textbook questions 1 to 5 of “Analyze,” p. 409**

1. Most earthquakes are located near volcanoes.
2. The pattern of earthquakes, volcanoes, and plate boundaries tends to follow the edge of the Pacific Ocean.
3. The pattern in the Atlantic Ocean is different from that in the Pacific Ocean. There are few earthquakes or volcanoes along the edges of the Atlantic Ocean.
4. Most earthquakes in North America occur along the Pacific Coast.
5. A large number of earthquakes and volcanoes appear along the west coast of South America, in Southeast Asia, along the Mediterranean Sea, and in Central Asia.

- b. **Textbook questions 6 and 7 of “Conclude and Apply,” p. 409**

6. There is a definite pattern. Active earthquake and volcano zones appear along the edges of tectonic plates.
7. Earth's crust is more active along plate boundaries.

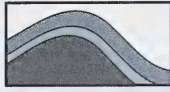
4. The largest volcano in the solar system is the extinct Olympus Mons on Mars.

5. **Textbook questions 1 to 4 of “Topic 6 Review,” p. 411**

1. Volcanoes form where plate and rock movement occurs. Magma rises through fissures to the surface.
2. Earthquakes and volcanoes are a result of crustal movement.
3. The Ring of Fire is the circle of volcanoes around the Pacific Ocean. Its name refers to the number of volcanoes that surrounds the “ring.”
4. Volcanoes might be found along the coast of British Columbia, the Coast Mountain Ranges, and the Cascades. (That is along the west coast.)

Section 2: Lesson 4

1. An *anticline* is the folded, stratified rocks that slope downward from the crest of folded rock.



A *syncline* is a trough or downward fold in sedimentary rock strata.



A *thrust fault* is a fault in which rock above the fault moves upward.

A *fault block mountain* is a mountain formed by thrust faulting.

A *complex mountain* is a mountain formed by folding and faulting.

2. No, sediments cannot be deposited in the pattern illustrated in Figure 5.66.
3. The temperature of the rock must be high enough for it to become pliable and bend.
4. Thrust faulting is also known as reverse faulting.
5. The Canadian Rockies consist of sedimentary rock at the surface. The American Rockies have basement rock thrust to the surface as well as sedimentary rock.
6. The Juan de Fuca plate is subducting under the North American plate.
7. Young mountains are higher and have a lot of exposed rock. Old mountains are lower because they have eroded over time and most of their rock is covered by eroded rock material.
8. Check your responses with your teacher or home instructor.
9. **Textbook questions 1 to 7 of “Topic 7 Review,” p. 416**
 1. Compressive forces place sedimentary rock under gradual pressure, causing it to fold into anticlines and synclines.
 2. Plates can collide or plates can pull apart. Both actions cause faults.
 3. A fault block mountain is formed in regions where faults exist and plate tectonics cause large blocks of crust to move along these faults.
 4. Complex mountains are the result of both folding and faulting of crustal rock.

5. An anticline is a folded, stratified rock that slopes downward from a crest. A syncline is a trough or downward fold in sedimentary rock strata. The presence of an anticline and syncline suggests that the rock was once hot enough to bend (like plastic) when subjected to compressive forces.
6. The Himalayas are getting higher due to a continued force, causing uplift. The Laurentians are under no uplifting force and are eroding away.
7. The Juan de Fuca plate is subducting under the North American plate. The leading edge of the continental plate is being folded, forming the Olympic Mountains.

Section 2 Review

1. and 2. Check your responses with your teacher or home instructor.

Section 3: Lesson 1

1. Many of the fossils in the Burgess Shale preserve soft-body parts of marine animals.

2.

Picture	Fossil Type
Figure 5.74	cast
Figure 5.76	trace fossil or mould
Figure 5.77	carbonaceous film
Figure 5.78	mould or cast
Figure 5.79	original remains
Figure 5.80	petrified
Figure 5.81	petrified

3. Check your responses with your teacher or home instructor.
4. Paleontologist need to be familiar with physics, chemistry, biology, geology, and astronomy.
5. **Textbook questions 1 to 4 of “Topic 8 Review,” p. 422**
 1. Fossils can identify the type of animals and plants that inhabited Earth. They can tell you when they first appeared and when they disappeared. Fossils may also indicate something about the behaviour of animals, the climatic conditions, and the environmental conditions in the past.
 2. The remains of animals and plants must be protected from scavengers and micro-organisms. They have a good chance of becoming one of the various fossil types if they are quickly covered by sediments, frozen in ice, fall into a pool of tar, or get stuck in tree sap.

3. Five types of fossils are

- **actual remains:** preserved in ice, amber, tar pool, or peat bog
- **petrified:** animal or plant remains buried and parts replaced by minerals
- **carbonization:** a preserved thin layer of carbon
- **mould and cast:** remains buried leave a mould that is later filled by minerals, leaving a cast
- **trace fossil:** indirect evidence of an organism's existence, such as animal tracks or nests

4. The hard parts (like bones) of living things are most likely to be preserved as fossils. Soft parts (like muscle tissue) decay rapidly.

Section 3: Lesson 2

1. The *principle of superposition* is a geological theory stating that the oldest layer in undisturbed layers of rock is on the bottom and the youngest layer is on the top.

A *strata* is a set of layers of sedimentary rock.

Relative dating is the dating of events by means of their place in a chronological order of occurrence.

An *index fossil* is a fossil used to determine the relative age of the layer of rock the fossil is found in.

2. The layers of sedimentary rocks are clearly visible, making the application of the principle of superposition easy.

3. **Textbook questions 1 and 2 of “What Did You Find Out?,” p. 423**

1. The fault is the line running up at an angle in the upper left of the diagram.

2. The cliff edges would be sharper if the faulting was recent. Also, the top of the cliff shows significant erosion.

4. *Half-life* is the amount of time a radioactive substance takes to be reduced by one-half.

Radiometric dating is a technique used to determine the age of a geologic specimen. It measures the relative amounts of radioactive particles the specimen contains.

Radiocarbon dating is a technique used to determine the age of organic remains. It measures the relative amount of radioactive carbon-14 contained in the remains.

5. Carbon-14 has a half-life of only 5730 years. After 50 000 years, there is too little left to measure it.

6. Textbook question “Math Connect,” p. 424

Because only $\frac{1}{4}$ of the carbon-14 remains in the sample, it has gone through 2 half-lives.

$$5730 \times 2 = 11\,460$$

The sample is 11 460 years old.

7. Textbook questions 3 and 4 of “Procedure,” p. 425

3. **top layer:** from 286 to 408 million years ago
middle layer: from 408 to 438 million years ago
bottom layer: around 505 million years ago

4. The middle layer was probably deposited between 438 and 408 million years ago.

8. Answers will vary. They should show that the geologic time scale consists of eons divided into eras, which are divided into periods. The eras Proterozoic, Archaean, and Hadrean are not given in the text. They are in the chart as extra information. The same is true for the Eon, Phanerozoic.

Eon	Era	Period
Phanerozoic	Cenozoic	Quaternary
		Tertiary
	Mesozoic	Cretaceous
		Jurassic
		Triassic
	Paleozoic	Permian
		Carboniferous
		Devonian
		Silurian
		Ordovician
		Cambrian
Precambrian	Proterozoic	
	Archaean	
	Hadrean	

9. Few life forms existed during the Precambrian. Those that did exist were soft bodied, thus leaving little fossil evidence.
10. The great coal deposits were formed during the Carboniferous period. The name makes reference to carbon.

11. a. **Textbook questions 1 and 3 of “What Did You Find Out?,” p. 427**

1. Most events seem to occur in the Paleozoic Era. By this time, Earth had a crust. There were land and oceans. There were many different niches for organisms to fill.
3. Answers will vary. Some improvements, like writing smaller and using a finer-point pen, should be suggested.

b. **Textbook question 4 of “Extension,” p. 427**

4. Answers will vary. Suggested additions should be correct for the period chosen.

12. **Textbook questions 1 to 4 of “Topic 9 Review,” p. 427**

1. The principle of superposition is a geological theory stating that the oldest layer is on the bottom of undisturbed layers of rock and the youngest layer is on top.

Geologists examine the position of rocks in the strata to determine the relative age of the rock. If the age of one layer is known, then the relative ages of the others can be determined.

2. Relative dating helps geologists find the order in which events occurred. Radiometric dating determines the absolute age of rocks and fossils.
3. The half-life of a radioactive substance is the amount of time it takes the substance to be reduced by half. For example, uranium-238 has a half-life of 4.51 billion years. So, it will take 2 g of uranium-238 4.51 billion years to reduce to 1 g (or half).
4. Earth is believed to be about 4.5 billion years old. Pangaea is the supercontinent that, based on fossil records, split into two portions about 200 million years ago. The northern portion was referred to as Laurasia. The southern portion was referred to as Gondwanaland. The breakup into smaller land masses continued about 180 million years ago, from which the present continents formed.

Section 3: Lesson 3

1. Animal and plant remains in sedimentary basins transform into fossil fuels due to constant pressure and heat over a long period of time.
2. Coal is usually formed from the remains of plants that grew on land.

Natural gas can be formed from either land-based or water-based plants and animals.

Oil is usually formed from water-based animal and plant remains.

3. An alternative theory proposed for the source fossil fuels is that hydrocarbons may have been trapped in the interior of Earth during its formation. Oil and natural gas have been rising to the surface since.
4. A major difference is the source of the seismic waves and how they are monitored. Earthquake waves are produced naturally by some form of rock movement and are monitored randomly by seismographs anywhere in the world. In seismic explorations, waves are produced by explosives and are monitored by carefully placed receivers close to the source.

5. a. **Textbook questions 1 to 4 of “Analyze,” p. 430**

1. You should drill for oil at a point that taps into the oil-bearing limestone. Both B and C are above the oil pool.
2. Points on the left half of the diagram would also tap into the same oil-bearing formation. A point about half-way between C and D would hit the higher pool of oil on that side of the area.
3. The blue limestone is the oldest rock because it is on the bottom.
4. A thrust fault occurred. The glacial till is not faulted because it was deposited after the faulting.

b. **Textbook questions 5 and 6 of “Conclude and Apply,” p. 430**

5. The geologic history begins with the formation of blue limestone, followed by layers of shale, sandstone, and another layer of shale. At this point, faulting occurs and the compression pushed the layers over top of one another. This formed an oil and gas trap. Finally, a glacier deposited the surface layer.
6. Your model should look like one of the cross-sections in Figure 5.91 on page 429 of the textbook.

6. **Textbook questions 1 to 4 of “Topic 10 Review,” p. 432**

1. Petroleum is a naturally occurring, complex, liquid hydrocarbon. It can be gaseous (natural gas), liquid (crude oil), solid (tar, bitumen), or a combination of states.
2. Coal is formed from the compaction of land plants. Oil is usually formed from the remains of marine plants and animals buried in silt. Over time, heat and pressure change them to oil. Natural gas is formed similar to oil, but it can be formed from either land-based or water-based plants and animals.
3. Geologists decide where to drill by studying surface rocks and core samples. Using this and seismic data, they try to locate fossil-fuel traps.
4. Some common products from fossil fuels are oil, natural gas, coal, kerosene, jet fuel, lubricants, plastics, waxes, tar, asphalt, and diesel oil.

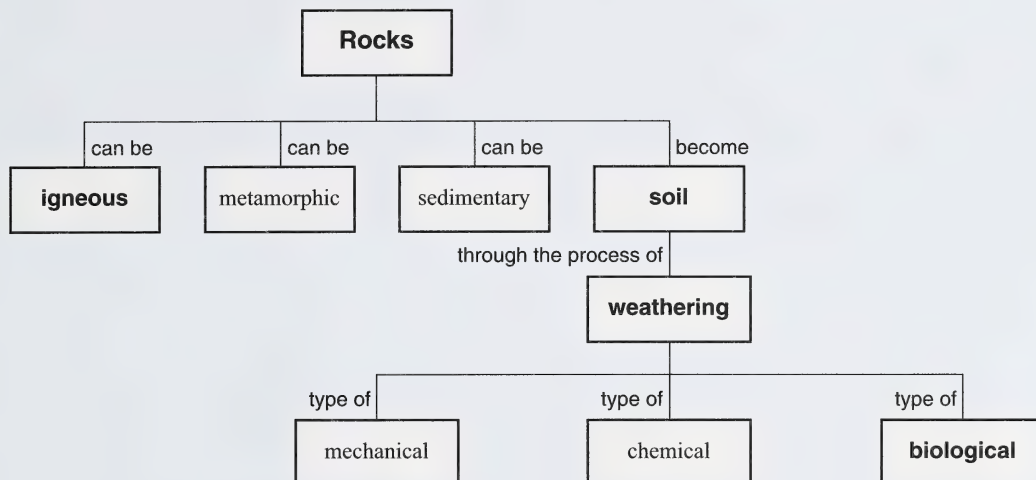
Section 3 Review

1. and 2. Check your responses with your teacher or home instructor.

Module Review

1. Textbook questions 1 and 2 of “Understanding Key Concepts,” p. 438

1.



2. If it can scratch an iron nail, it is harder than 4.5. If it cannot scratch glass, it is softer than 5.5. The mineral would have a hardness of about 5.

2. Textbook questions 6, 8, 9, and 10 of “Developing Skills,” p. 439

6. In Alberta, most local rocks are sedimentary. However, there are igneous and metamorphic outcrops in some areas.
8. Convection currents in the mantle are believed to be the power source for plate tectonics. This crustal movement is responsible for mountain building, volcanic activity, and earthquakes.
9. Geologists can identify the types of rock that make up the layers. They can determine the relative age of the layers from their position and fossil content. Geologists can also identify any faulting or folding that has taken place.

The principle of superposition helps determine relative age.

10. After 1 half-life, $40 \text{ g} \times 0.5 = 20 \text{ g}$ of parent material is left.
After 2 half-lives, $20 \text{ g} \times 0.5 = 10 \text{ g}$ of parent material is left.
After 3 half-lives, $10 \text{ g} \times 0.5 = 5 \text{ g}$ of parent material is left.

So, the fossil has gone through 3 half-lives.

$$5730 \times 3 = 17\,190$$

The fossil is about 17 190 years old.

3. **Textbook questions 12, 14, and 17 of “Problem Solving/Applying,” pp. 439 and 440**

- 12. No, igneous rock is solidified rock material. Any plant or animal remains would have been incinerated. The only possible exception is the potential for casts or trace fossils to be found in lava rocks.
- 14. The rock cycle demonstrates how all rock types can become sediments and become part of a conglomerate.
- 17
 - a. The term *epicentre* should be replaced with *focus*. The epicentre is a point at the surface above the focus.
 - b. Kobe is a highly populated city with many high-rise buildings. The Bolivian earthquake occurred in a largely rural area.

4. **Textbook questions 21, 22, 24, 27, and 30 of “Critical Thinking,” pp. 440 and 441**

- 21. Igneous rocks with holes in them are very likely extrusive because they form at the surface of Earth. When lava cools, gas dissolved in it separates to form bubbles. These bubbles are left as holes in the volcanic rock.
- 22. In mechanical weathering, water freezing and thawing in fissures is responsible for frost wedging. Also, glacier ice and moving water carrying sediments scrape the surface they move over.

Water dissolves substances, forming acids that react with rock during chemical weathering. Water also contributes to leaching mineral out of rock and soil material and transporting to other layers.
- 24. Most earthquakes, volcanoes, and mountains are found at or near major tectonic plate boundaries. Japan, Italy, and the United States are three countries that have active volcanoes, earthquakes, and mountains.
- 27. Trilobites are an index fossil. They lived for a short period of time in warm ocean water and were widespread. Their presence in Alberta indicates that the area was covered by a very large ocean during the Paleozoic era, about 250 million years ago.
- 30.
 - a. Just one pump is lifting oil up to the surface.
 - b. The pump on the right is lifting oil to the surface.
 - c. The pump on the left is pumping water down to the bottom of the oil-bearing layer. The water helps to separate the oil from the rock. Oil is less dense than water; it floats on top of the water. This helps push the oil to the surface.

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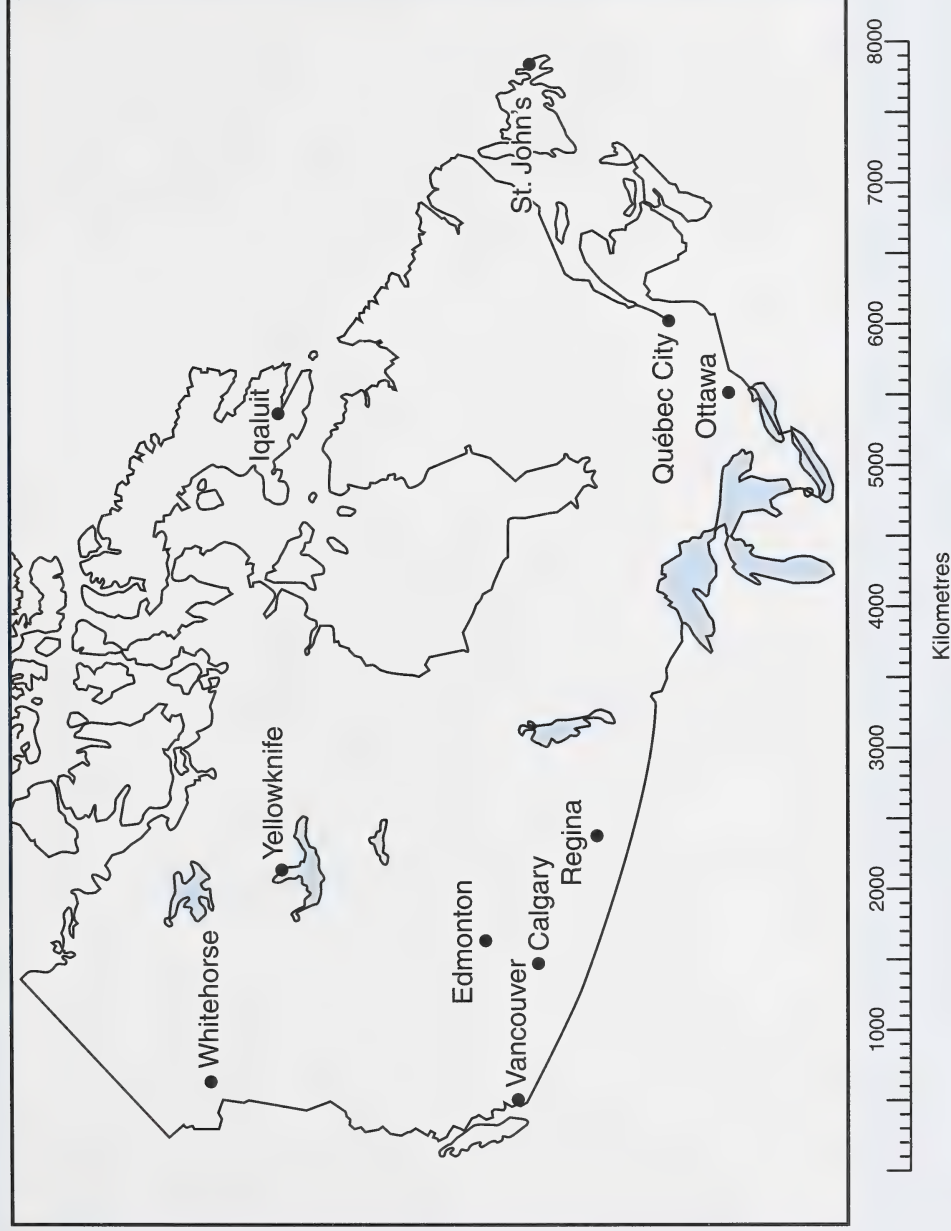
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21	© 2002–2003 www.clipart.com	60	PhotoDisc Collection/Getty Images
22	top: © 2002–2003 www.clipart.com	61	bottom: PhotoDisc Collection/Getty Images
	middle: PhotoDisc Collection/Getty Images	62	bottom: © 2002–2003 www.clipart.com
23	PhotoDisc Collection/Getty Images	63	top: © 2002–2003 www.clipart.com
24	right: PhotoDisc Collection/Getty Images	65	PhotoDisc Collection/Getty Images
	left: Corel Corporation	66	top: PhotoDisc Collection/Getty Images
25	© 2002–2003 www.clipart.com		bottom: Corel Corporation
28	bottom: © 2002–2003 www.clipart.com	67	PhotoDisc Collection/Getty Images
29	top: Corel Corporation	68	© 2002–2003 www.clipart.com
	bottom: PhotoDisc Collection/Getty Images	69	both: PhotoDisc Collection/Getty Images
30	top: PhotoDisc Collection/Getty Images	71	both: PhotoDisc Collection/Getty Images
	bottom: © 2002–2003 www.clipart.com	72	PhotoDisc Collection/Getty Images
31	top: © 2002–2003 www.clipart.com	73	© 2002–2003 www.clipart.com
	bottom: PhotoDisc Collection/Getty Images	74	bottom: PhotoDisc Collection/Getty Images
32	all: © 2002–2003 www.clipart.com	75	PhotoDisc Collection/Getty Images
34	PhotoDisc Collection/Getty Images	76	both: PhotoDisc Collection/Getty Images
35	top and middle: PhotoDisc Collection/Getty Images	77	PhotoDisc Collection/Getty Images
	bottom: Corel Corporation	78	PhotoDisc Collection/Getty Images
36	both: PhotoDisc Collection/Getty Images	80	both: PhotoDisc Collection/Getty Images
37	PhotoDisc Collection/Getty Images	81	all: PhotoDisc Collection/Getty Images
38	both: PhotoDisc Collection/Getty Images	82	top: PhotoDisc Collection/Getty Images
39	bottom: Corel Corporation		bottom: © 2002–2003 www.clipart.com
40	PhotoDisc Collection/Getty Images	83	top: PhotoDisc Collection/Getty Images
41	PhotoDisc Collection/Getty Images		bottom: © 2002–2003 www.clipart.com
42	both: Corel Corporation	84	© 2002–2003 www.clipart.com
43	top: Corel Corporation	85	both: PhotoDisc Collection/Getty Images
	bottom: PhotoDisc Collection/Getty Images	86	both: © 2002–2003 www.clipart.com
44	top: PhotoDisc Collection/Getty Images	87	PhotoDisc Collection/Getty Images
	bottom: Corel Corporation	88	top: PhotoDisc Collection/Getty Images
46	top: PhotoDisc Collection/Getty Images		bottom: © 2002–2003 www.clipart.com
	bottom: © 2002–2003 www.clipart.com	89	PhotoDisc Collection/Getty Images
47	EyeWire Collection/Getty Images	90	both: PhotoDisc Collection/Getty Images
48	PhotoDisc Collection/Getty Images	91	both: PhotoDisc Collection/Getty Images
		92	PhotoDisc Collection/Getty Images
		93	collage: PhotoDisc Collection/Getty Images

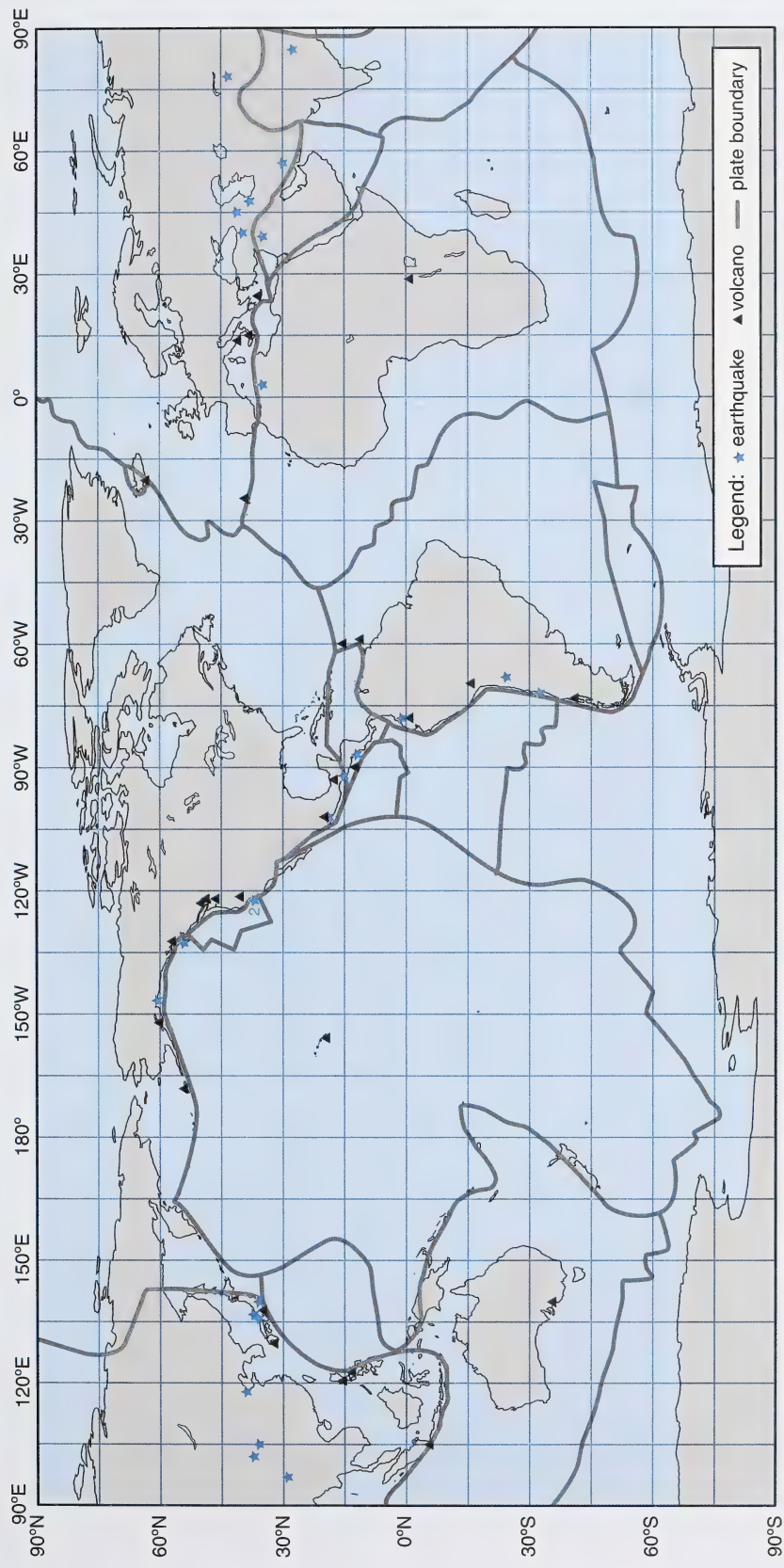
Investigation 5-F: Give Me a Clue!



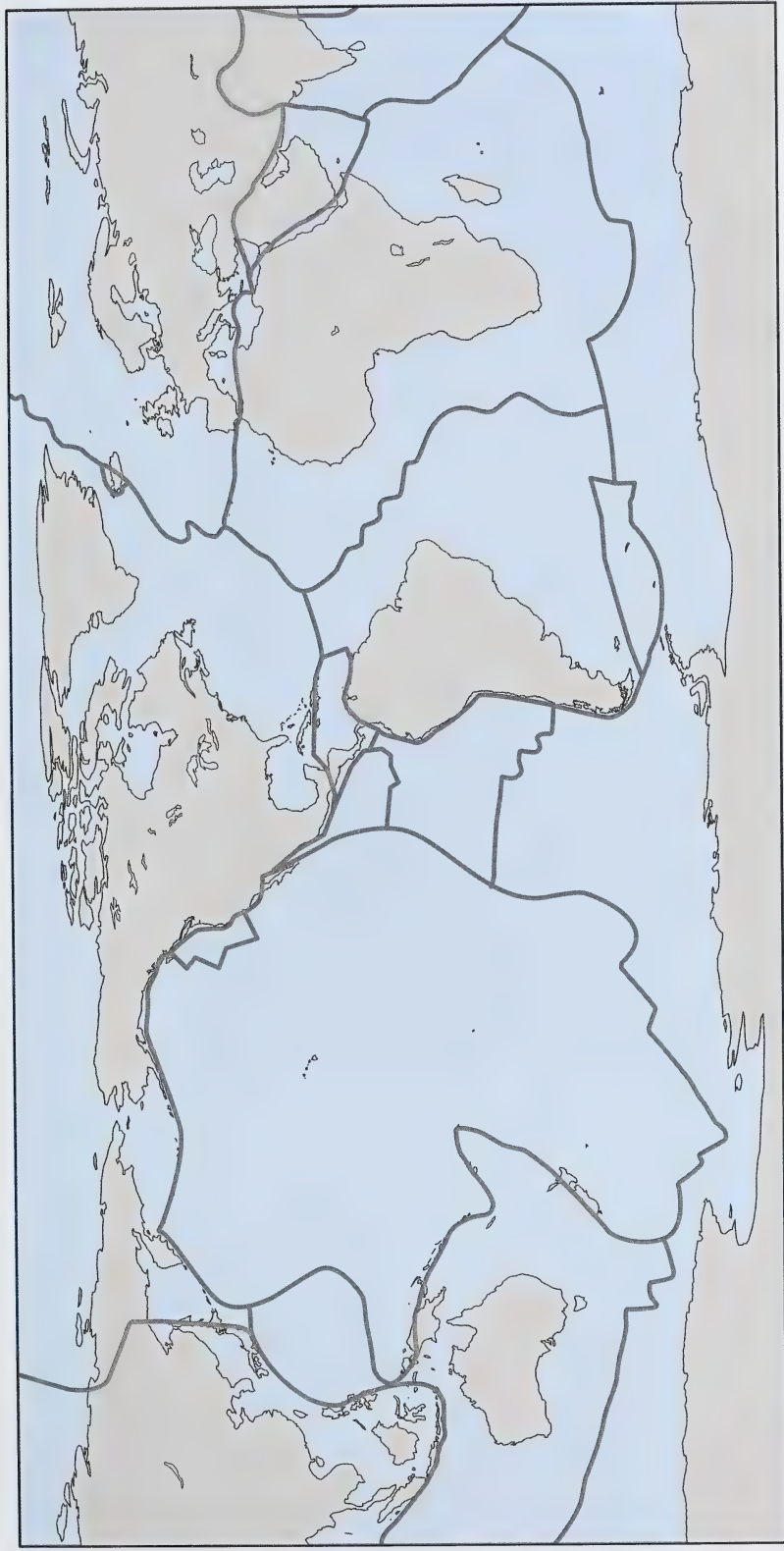
Investigation 5-H: Locate the Epicentres



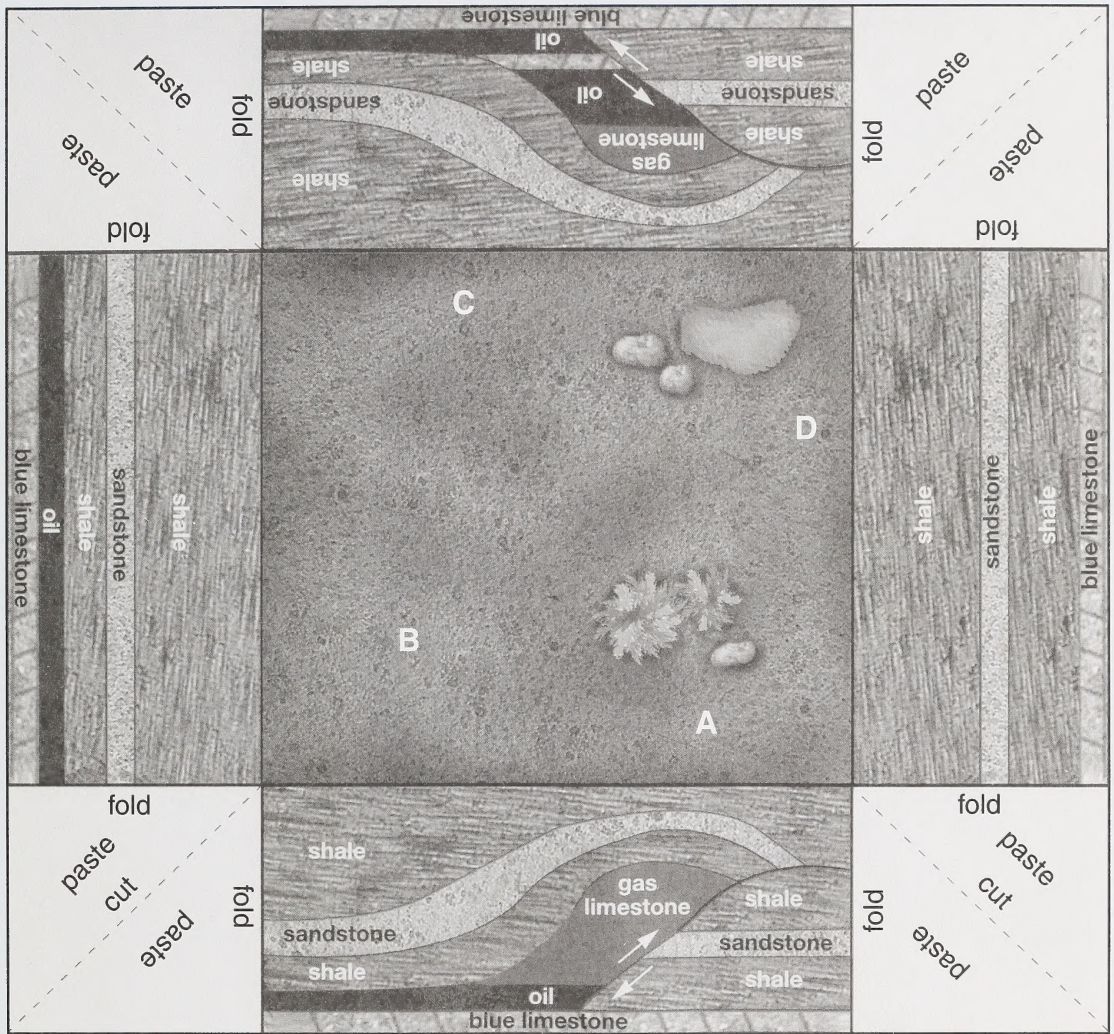
Investigation 5-J: Patterns in Earthquake and Volcano Locations



Investigation 5-K: Building a Mountain-Building Theory



Investigation 5-M: Where Shall We Drill?



Notice the types of rock in this model.

- blue limestone
- shale
- sandstone
- shale

The surface of the area has a covering of glacial till. This was deposited at the end of the last ice age. (It ended about 10 000 years ago.)

~w